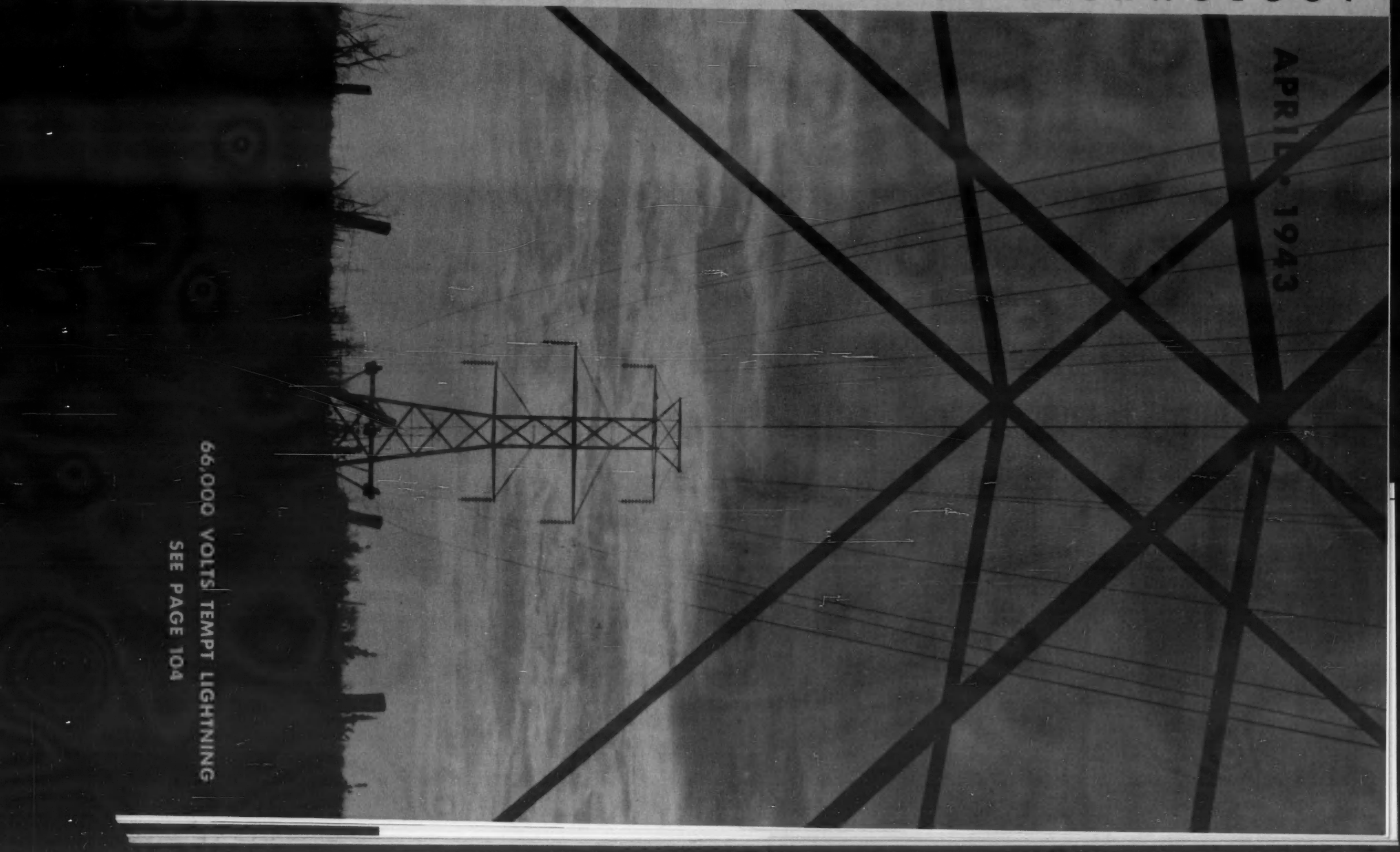
TECH ENGINEERING NEWS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APRIL, 1943



66,000 VOLTS TEMPT LIGHTNING

SEE PAGE 104

Information supplied by an Industrial Publication

Several means are being applied industrially to save time and reduce fatigue of welders working on heavy jobs. Positioning tables, rotating jigs and similar devices for handling heavy or bulky assemblies are quite generally used.

One aircraft manufacturer has adopted a similar idea for welders working on small sub-assemblies. The assemblies are light, and joints are usually quite accessible. But moving the assemblies by hand does occasion some delay.

This is obviated by mounting the work on a small turn table somewhat resembling an old style potter's wheel. The turn table is quite simple, consisting of two round plates mounted on a common shaft.

The upper plate carries the work, and is located at a convenient height above a work table. The lower plate is a few inches above the shop floor. It is positioned so that the operator's feet rest on it comfortably.

Thus, when the operator wishes to move the work, he simply "indexes" the lower table by foot power. The weight of his feet on the plate is, however, sufficient to hold the whole turn table steady while he is welding any particular joint.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE BRIQUETTES • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Mo-lyb-den-um Company
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MOLY

Speaking of superior races . . .

Every wheel that rolls on the battlefield turns in a polished bearing race, ruggedly built to take the terrific shock of combat service.

To withstand such punishment, bearing races must be hardened by heat-treatment. Hard and soft spots occasionally occur. Such races may fail—at times when failure means disaster.

Recognizing the vital need, Westinghouse Research Engineers P. H. Brace and C. S. Williams set to work to develop a quick, sure method of detecting these flaws.

Their ingenious electromagnetic flaw-detector is based upon the fundamental law that the *permeability* of a heat-treated steel part varies with the degree of hardness.

In actual practice, Brace and Williams first *completely* demagnetize the bearing race under test. Next it is rapidly rotated and strongly magnetized. While the race is still turning at high speed its magnetic field is explored with a specially designed electromagnetic "pick-up."

Variations in the magnetic field of the bearing race, due to hard or soft spots, induce feeble currents in the pick-up system. These currents are amplified and shown on a cathode-ray oscilloscope.

A uniformly heat-treated bearing race traces a *luminous straight line* on the oscilloscope screen. Faulty heat-treating shows up as a pattern of *hills and valleys.*

The Brace-Williams electromagnetic flaw-detector is now being used commercially—a typical example of Westinghouse *electronics at work.* It assures quality in millions of bearing races for our armed forces, *to keep 'em rolling on to victory!*

★ ★ ★

What Brace and Williams did—by employing Westinghouse "know how" to develop the magnetic flaw detector—many young Westinghouse scientists are now doing in other fields of fundamental research.

Today, they are helping to solve the technical problems of modern warfare. Tomorrow, they will tackle the job of building a better world for all of us.

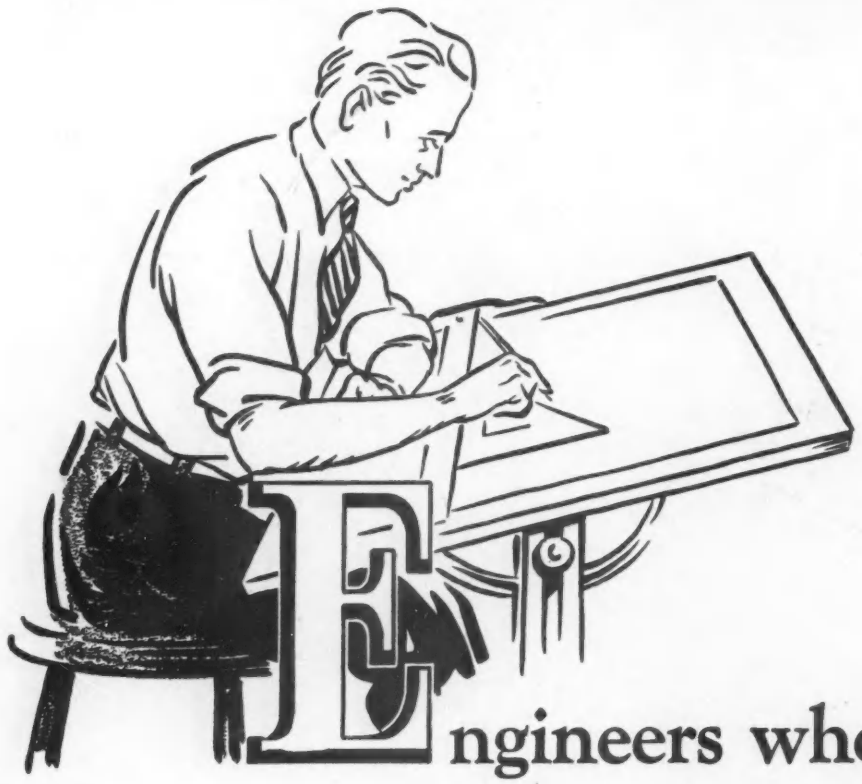
Westinghouse Electric & Manufacturing Company, Pittsburgh, Pennsylvania.

ELECTRONIC FINGERPRINTS—Westinghouse Research Engineer C. S. Williams demonstrates the principle of the electromagnetic flaw-detector. Hard spots in the steel test piece show up as an irregular line on the oscilloscope screen. Williams joined Westinghouse after receiving his B. S. in Electrical Engineering at Northwestern University.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electronics at work



Engineers who know their bearings are helping to win the war

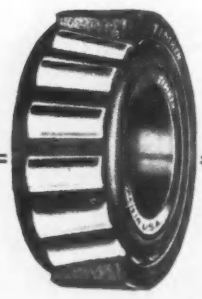
Timken Tapered Roller Bearings in untold millions have gone and constantly are going into American fighting equipment and the industrial machines that produce it—placed there by engineers who know from years of experience what Timken Bearings can do.

Many of these veteran engineers began to acquire their knowledge of Timken Bearings while in college, and if you asked them they would tell you that this has been an important factor in their success.

For there is no bearing problem, however complex, that cannot be solved by the multiple abilities of Timken Bearings — the total elimination of friction; the safe carrying of radial, thrust and combined loads; and the holding of moving parts in correct and constant alignment.

Begin now to obtain *your* knowledge of Timken Bearings.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO



TIMKEN

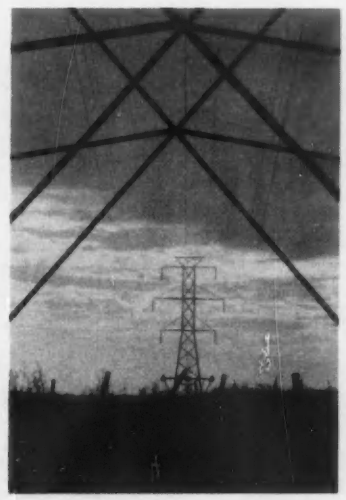
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

"ALL THERE IS IN BEARINGS"

THE TECH ENGINEERING NEWS

APRIL · 1943



COVER

This transmission tower of a 66,000 volt power line illustrates the increasing tendency to link together power systems of the nation for flexibility and reliability. The uninterrupted service of these systems is of utmost importance now ***(see page 104.)***

VOLUME XXIV

NUMBER 5

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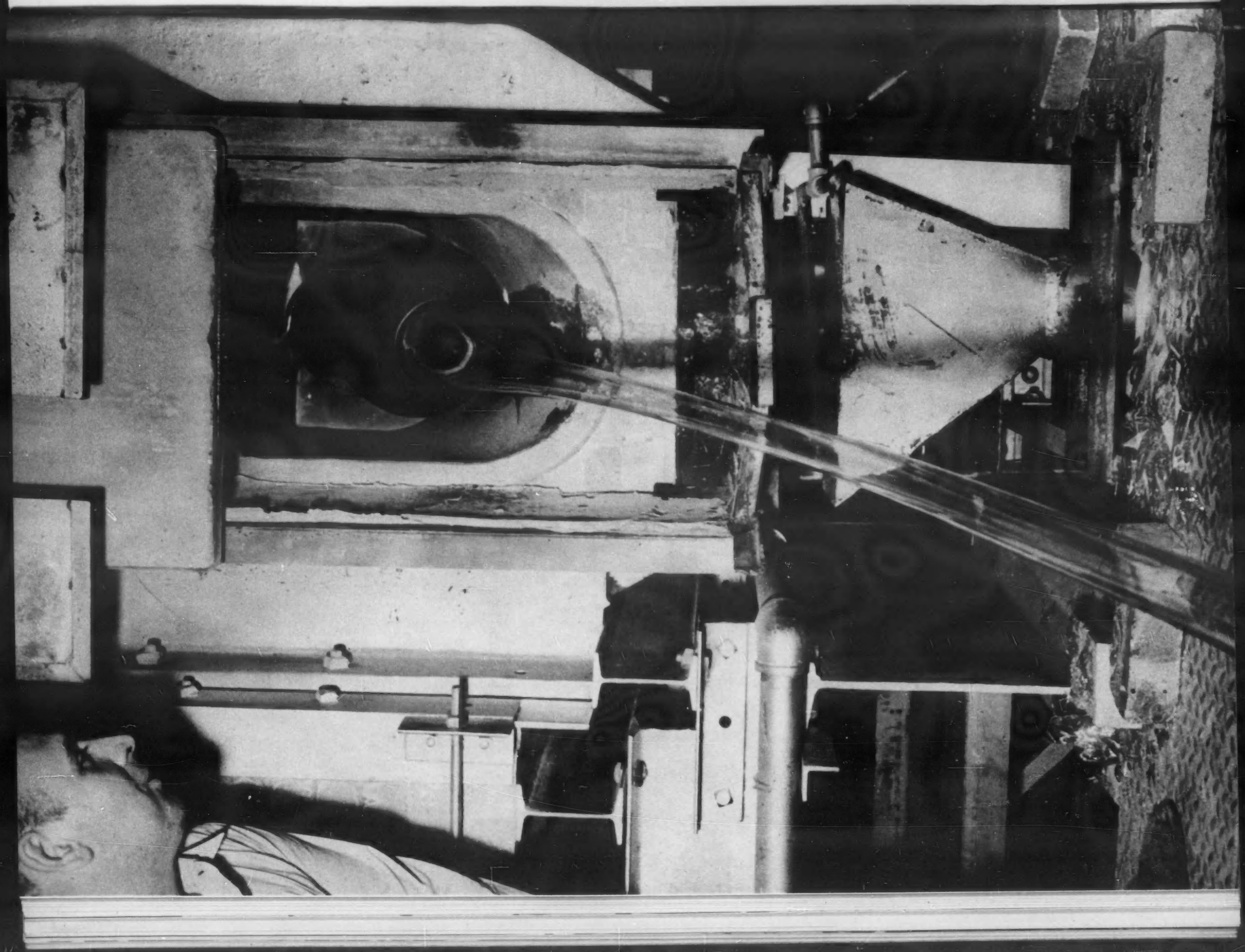


FROM BLACK LIGHT TO WHITE

BETTER PHOSPHORS FOR THE CONVERSION OF ULTRA-VIOLET LIGHT INTO VISIBLE LIGHT IN FLUORESCENT LAMPS

By GORDON R. FONDA

NOTABLE improvements in the quality of any manufactured article come as the result of specific developments. It is of course true that the laboratory worker is generally embarrassed to find that the mass production in a factory turns out a superior article to what he had discovered on his bench, but this is simply the result of that proper control of details which characterizes good factory procedure. The laboratory worker is still responsible for the major improvements. The steps that led to them are not always known except to those technically involved. It is in this respect that the electric lamp as used in households is rather unique. A distinctive name has been given to each of the major improvements which have resulted in the phenomenal increase of twentyfold in efficiency in less than sixty years.

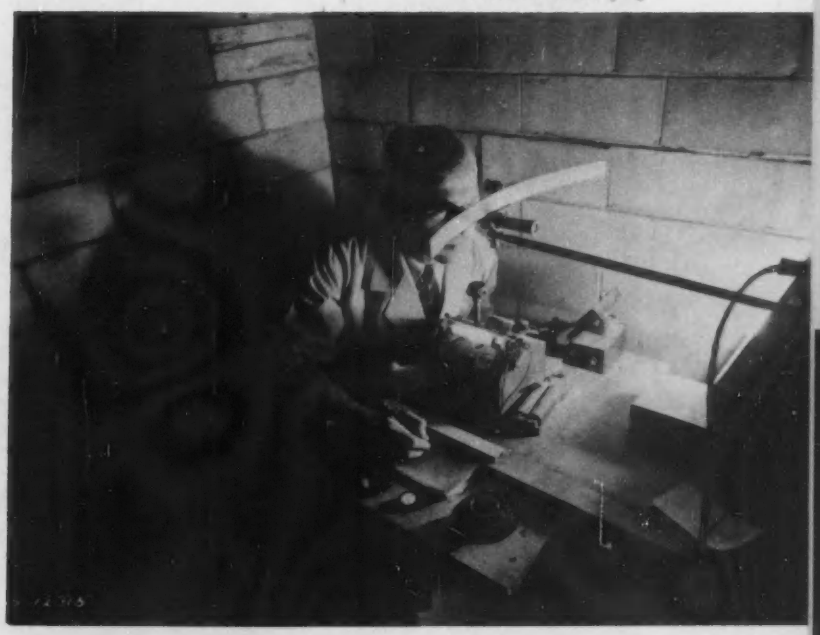
The first carbon filament lamp of Edison in 1881 had an efficiency of 1.7 lumens per watt, which was doubled to 3.4 by 1906. Then came, in rapid succession, the Gem lamp with a "metallized" carbon filament, operating at 4.3 LPW, the tantulum filament lamp at 4.8 LPW, the osmium filament lamp at 5.9 LPW, and the tungsten filament lamp at 10 LWP. The next advance was to the gas-filled lamp, ranging as high as 18 LPW in the larger sizes. This remained the ultimate for over twenty years.

A few years ago there came a radical departure. For over fifty years the electric lamp had utilized an incandescent filament as the source of its illumination. The steps in its development had been represented by changes in the choice of metal for the filament and finally by the substitution of an inert gas at atmospheric pressure for a vacuum. This traditional line of development was interrupted by the appearance of the fluorescent lamp. Not only did it make possible the surprising jump in efficiency to 35 LPW for white light but it represented a new and different type of lamp with an entirely different family tree. Its roots ran in surprisingly different directions.

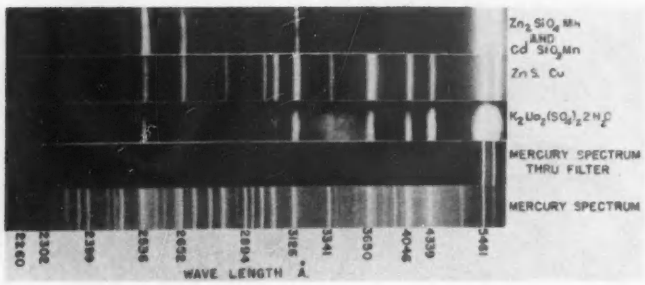
It is not enough to say that the fluorescent lamp is made up of a glass tube coated with a fluorescent material whose luminescence is excited by an electric discharge within the tube. Such combinations had been tried earlier but never with any noteworthy success. There are many different types of electric discharges, and there are still more varieties of fluorescent materials, known as phosphors. The success of this new lamp lay, to begin with, in the selection of a type of discharge and of phosphors between which an advantageous correlation existed. It was necessary to choose a discharge whose predominant radiation lay in the ultraviolet, and the choice of phosphors was limited to those whose luminescence is excited by wavelength regions in the ultraviolet that are radiated by the discharge. There were other essential requirements. The light emission of the various phosphors used must so overlap that their composite emission curve is close to that of white light. Their emission, as a further requirement, must be generated at a high quantum efficiency, and it should include some phosphorescence, *i.e.*, a persistence of light emission after extinction of the excitation, for only in that way can flicker on AC circuits be avoided.

Gordon R. Fonda is a graduate in physical chemistry of New York University and of the Technische Hochschule of Karlsruhe, Germany. For the past thirty years he has been a member of the Research Laboratory of the General Electric Company at Schenectady, N. Y. He has published elsewhere papers on various subjects, including the separation of the rare gases, the operation of incandescent lamps, thermionic emission, X-ray spectroscopy, sodium vapor lamps, and fluorescence and phosphorescence.

Testing brightness of fluorescent powders used in lamps
General Electric Company

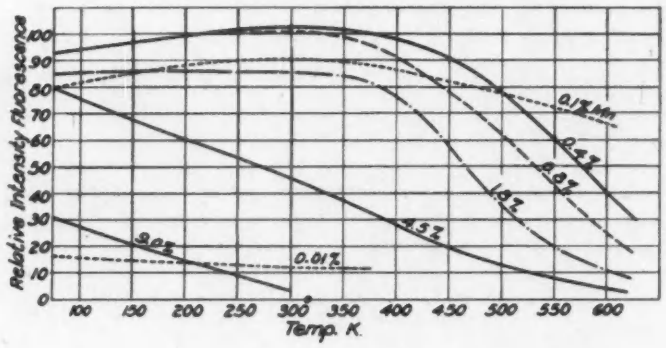


Glass tubing for fluorescent lamps emerging from furnace in liquid form
General Electric Company



General Electric Company

Fig. 1. Excitation spectra of phosphors



General Electric Company

Fig. 2. Variation in fluorescence of zinc silicate phosphors with temperature for various percentages of manganese

Moreover, the discharge should preferably have a low light emission in the visible range so as not to distort the light emission of the lamp by the appearance of line emission at exaggerated intensities.

These conditions were realized, so far as the discharge is concerned, by the choice of the low pressure mercury discharge in which over ninety per cent of the emitted radiation appears in the ultraviolet line, 2537Å, representing a conversion of about fifty per cent of the input electric energy into radiation of this wavelength.

The choice of suitable phosphors was equally difficult. The best known and most studied were of the sulfide type, but they proved to be completely unadaptable to the low pressure mercury discharge. They are excited very strongly by the near ultraviolet but show only weak responses below 3000Å. Extended tests brought out, however, that there were other less known phosphors, including certain silicates, borates, and tungstates, which were extremely well adapted, because they were excited predominantly by radiation in the neighborhood of 2537Å. This is brought out by Figure 1, which is a photographic record of the excitation spectra of several phosphors. It was obtained by coating a strip of phosphor on the outer surface of a plate of glass and placing this on a photographic plate with a yellow filter in between. The spectrum of a normal mercury discharge was then focussed upon the layer of phosphor and an exposure made. Because of the filters the photographic plate was able to record only the fluorescent light. Consequently, it displayed a pattern of lines which corresponded in position with the ultraviolet lines that were capable of exciting fluorescence and whose relative intensity, as compared with a direct exposure of the mercury lines, was a measure of the degree of excitation. The photographs in Figure 1 bring out the strong contrast between the silicates, which are excited only by the far ultraviolet, and the sulfide and uranyl phosphors whose excitation is most strong in the near ultraviolet.

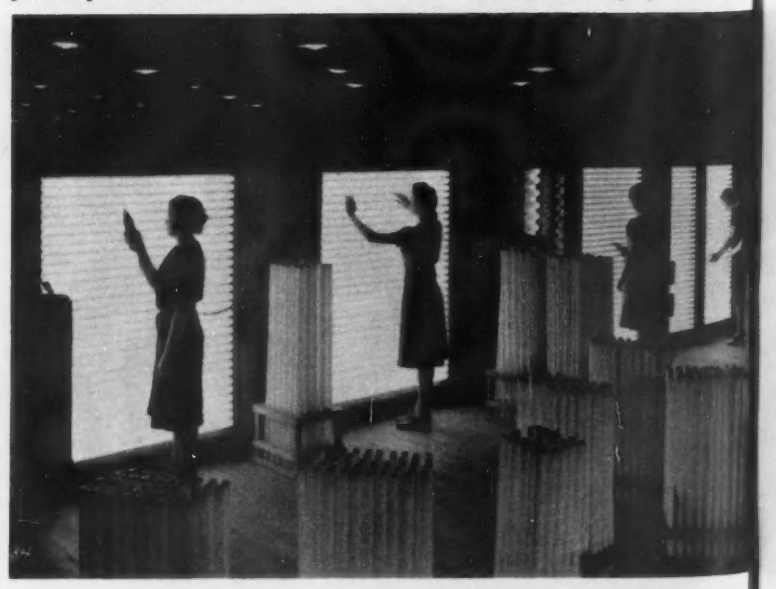
There is still a further requirement, that the process of conversion of the 2537 ultraviolet energy into visible fluorescent energy shall represent a high quantum yield. Actually, this is very favorable for the phosphors mentioned. For zinc silicate, for instance, one quantum of fluorescence energy is produced by 1.13 quanta of 2537Å energy.

Such a high conversion yield results, of course, only when the phosphors are prepared under the optimum conditions. To illustrate some of these, synthetic willemite can be taken as an example of one of them. It is a zinc silicate containing a small amount of manganese as activator. Despite its low concentration, the activator is essentially the luminophor or light-emitting agent. The underlying process of light formation involves an excitation of the manganese atoms by the 2537Å radiation, consisting in an ejection of electrons to outer orbits. The fluorescent light is emitted by the return of such excited electrons to their normal orbits. In this respect, the process of light emission is similar to the generation of resonance radiation in a gas whose low pressure is the equivalent of the low concentration of the manganese atoms in the silicate. In a phosphor, however, the situation is so complicated by the presence of the basic solid compound and by the resulting interplay of forces between its constituent atoms and the manganese atoms that the fluorescence appears as a broad band rather than as a line and is displaced to a spectral region that is longer in wave length than that of the exciting radiation.

The fluorescence light output under excitation by the 2537Å line has been measured for several different concentrations of manganese and at several different temperatures. The results are given in the curves of Figure 2. It is evident that the fluorescence at first rises proportionally to the manganese content. At about 0.4 per cent, however, the light output is reduced as the concentration of manganese is further increased, denoting that a disturbing influence has arisen. This can be ascribed to the loss in energy of an excited manganese

Finished fluorescent lighting tubes on racks for inspection and test

General Electric Company



atom by collision with neighboring manganese atoms as a consequence of the mobility allowed by thermal vibrations. The general increase in fluorescence that accompanies decreases in temperature and consequently in the amplitude of thermal vibrations is in accord with this conception. It is most noteworthy, as it should be, for those phosphors that are high in manganese concentration.

The normal fluorescence color of the zinc silicate-manganese phosphors is green. It can be displaced to longer wavelengths in two ways. One of these, employed more often commercially, is the introduction of beryllium which allows of the attainment of a variety of shades from yellow into the red. There are other instances in which the introduction of a related element serves to shift the emission band to longer wavelengths. Another way of obtaining a similar result is altogether different in nature. When the crystallization of the zinc silicate is so checked that it forms a colloidal complex with an excess of silica present, a yellow-emitting phosphor results. This is done either by forming the silicate from its ingredients at such a low temperature that appreciable grain growth is prevented or else by fusing it and chilling so rapidly that grain growth again is severely retarded. The normal green-emitting silicate has a definite crystal structure and gives a characteristic X-ray pattern. In the case of the yellow-emitting silicate this pattern is absent and only the pattern of silica appears, accompanied by much diffuse, scattered radiation, indicating an extremely fine division of the silicate, bordering on the colloidal. It is to this aggregate of a colloidal zinc silicate dispersed over crystallized silica, that the shift in emission is to be ascribed.

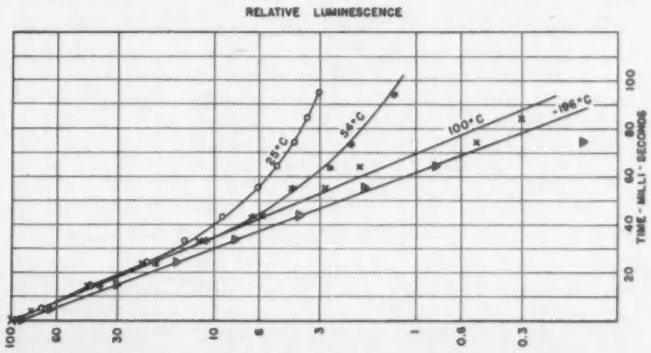
Another highly desirable feature of the phosphors used in the fluorescent lamp is that their initial phosphorescence decay be so slow that their light output is sufficient to tide over the gap between cycles of an AC circuit and thereby prevent serious flicker. Fortunately the silicates and borates have suitable decay curves for this purpose.

A striking feature in the decay of their phosphorescence is the presence of two separate stages. The first stage shows an exponential rate of decay and, for zinc silicate at room temperature, persists for about 0.04 sec, until the phosphorescence has fallen to 10 per cent or less of its initial value. Then it passes into a second stage, showing a much slower rate of decay, with a luminescence that is still observable after an hour in a darkened room. The distinction is brought out by the curves of Figure 3 measured at four different temperatures. It is interesting to note the differences manifested in the second stage of decay. This stage of decay is most pronounced in the test at 25° C. When the temperature is lowered to −196° C., it is completely absent but only because it is latent; for when the phosphor is warmed to about 0° C., there is an emission of light which then decays slowly in accord with the characteristics of the second stage. When on the other hand the test is carried out at temperatures above 25° C., the second stage of decay becomes less and less evident until at 100° C. it is completely absent and fails to reappear under any treatment.

To account for this second stage of decay, therefore, it is necessary to assume that excited electrons from manganese atoms are retained in a metastable state which is of the nature of a potential cup in that it offers resistance to the return of these electrons by the presence of a potential barrier. The relation between the height of the barrier and the energy content of the electrons is strongly dependent upon temperature. At −196° C. it is so high as to retain the electrons indefinitely. It is lowered progressively by increases in temperature until at 100° C. it has become so low that hardly any electrons are retained in the state with the result that this stage of decay is virtually absent. There are grounds for assuming that such a metastable state is associated with the presence of lattice imperfections in that the various agents which favor crystal distortions also serve to amplify the magnitude of the second stage of decay. The first and rapid stage of decay is to be ascribed to excited electrons which are left relatively free by saturation of the metastable states.

By reason of these various characteristics, the fluorescent lamp represents a much closer approach to the ideal illuminant than the previous incandescent filament lamps. Its light emission can be made to approximate daylight. It shows no more flicker than that of a 15-watt filament lamp, as a result of the phosphorescence of some of its phosphors. Its conversion of ultraviolet energy into light is high, ranging in terms of quantum efficiency from 50 to 70 per cent for the various phosphors utilized. Its conversion of electric energy into effective ultraviolet energy is about 55 per cent. Consequently, the conversion of electric energy into white light is much greater than that of any other type of illuminant at present known.

Fig. 3. Decay of phosphorescence at different temperatures of a zinc silicate phosphor containing 1.0 per cent manganese *General Electric Company*



Light output test *General Electric Company*

THOR VS. KILOWATTS

HOW POWER TRANSMISSION LINES ARE PROTECTED AGAINST LIGHTNING

By BERNARD G. TREMBLAY, '39

FROM the very start of the electric utility business, lightning has been the greatest enemy to dependable distribution and transmission of power, and only comparatively recently have the phenomena become even partly understood. For this reason, it seems desirable first to review briefly the formation and characteristics of the thunderclouds which produce the lightning, before explaining the various protective methods for transmission lines.

It is quite generally accepted that the charge in thunderclouds is closely connected with rising air currents caused by convection. The exact manner in which these convection currents give rise to charge formation in thunderclouds is not completely known. A number of theories have been advanced to explain this, but only three have received very much consideration, those of Simpson, Elster and Geitel, and Wilson.

Simpson, whose theory is probably best known and most generally accepted of the three, contended that the rising air currents' broke the raindrops, releasing negative ions into the air while the water drop became positively charged. Thus, with a repetition of this process, more and more negative ions are liberated and transported to the upper regions of the storm. The raindrops acquire a higher and higher positive charge and accumulate in the lower part of the cloud in a restricted region. This gives the upper part of the cloud a negative polarity and the lower part a positive polarity.

Elster and Geitel, like Simpson, suggested the formation of raindrops and their separation by the rising air currents. In addition they contended that there is a separation of electricity on each drop due to the negative field of the earth. With such an orientation on the drop itself, there takes place a transfer of positive and negative electricity between drops when two of them collide together. The rising smaller drops become positively charged and the larger falling drops gain equal amounts of negative electricity. This gives the upper part of the cloud a positive polarity and the lower part a negative polarity.

Wilson explains his theory by following the progress of the water drops through the rising air currents, but attributes their electrification to contact with air ions. As in the Elster and Geitel theory, Wilson also claims the separation of charge within the drop due to the earth's field. Drops falling toward the earth faster than the velocity of positive ions will attract negative ions and become negatively charged. Drops falling more slowly than the positive ions will attract them to their upper surface and become positively charged. The smaller droplets traveling upward will similarly become positively charged. This, like the Elster and Geitel theory, will make the upper cloud of positive polarity and the lower cloud of negative polarity.

Confirming these three theories, laboratory experiments have shown that when drops are broken up in an air stream they become electrified. However, there is still one serious discrepancy. That is, laboratory experiments indicate that the water drops become positively charged in breaking and, therefore, make the lower part of the cloud of positive polarity. However, measurements of lightning-discharge currents through transmission line towers indicate that a very high percentage of the strokes striking transmission lines are from negative clouds.

The electrical charge concentrations within a cloud in most cases cover only a very small portion of the cloud called the discharge center and usually occur at the front of the storm. This discharge center will, however, shift about considerably since the conditions that supply the moisture depend on the topographical conditions which are continually changing. These different topographical conditions give us five general types of thunderstorms. These are the heat, the mountain, the cold front, the overrunning cold front, and the warm front thunderstorms. The different types of storms have no particular significance to the stroke on the transmission line except insofar as they create conditions favorable for cloud to cloud discharges or cloud to ground discharges and affect the initial location of the line in certain localities.

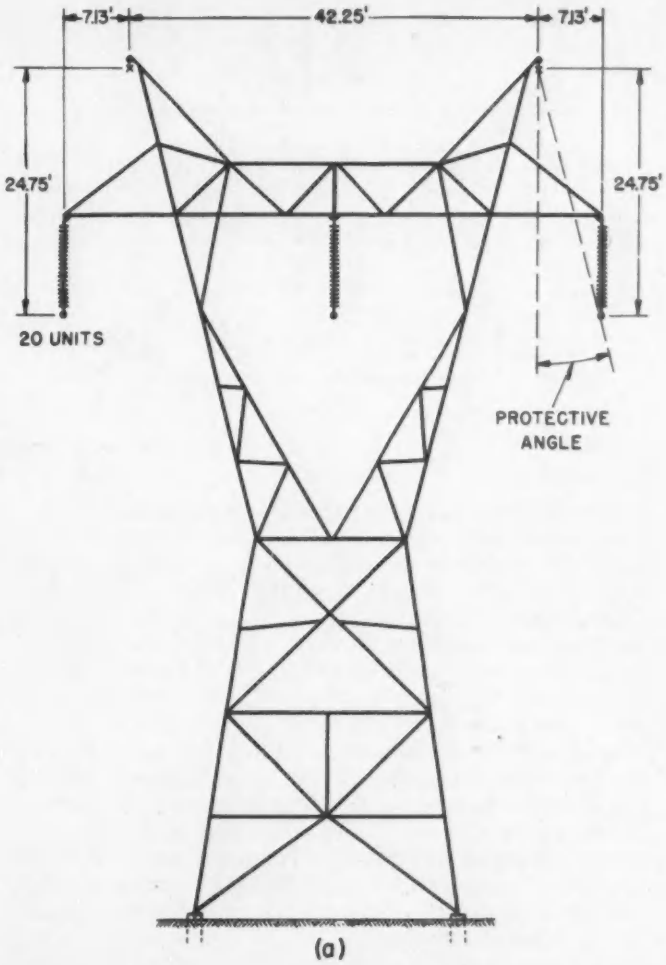
Field data have proven quite conclusively that cloud to cloud discharges have little or no effect on transmission lines. A few years ago, it was also shown that cloud to ground strokes that did not strike the transmission line were of little consequence to the line. It was at this same time that Dr. Fortescue's "direct stroke theory" became widely accepted in preference to the "induced stroke theory." Actual records showed on that occasion that lightning had struck the ground only 200 feet from the transmission line and in spite of this the klydonographs and the cathode ray oscillographs showed no surge on the transmission line.

Bernard G. Tremblay, design engineer with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania, was born January 27, 1917, in Salem, Massachusetts. After graduation from Salem Classical High School, he studied mechanical engineering at Massachusetts Institute of Technology, receiving his B.S. in 1939 and his M.S. in 1940. While at M. I. T., he took the mechanical engineering co-operative course with General Electric, and was a member of the board of directors of the "5:15 Club." Except for a month with the Sunbeam Electric Manufacturing Company, Mr. Tremblay has been with Westinghouse since his graduation in 1940, and for the last two years he has also been teaching in the Westinghouse Technical Night School. He has designed mechanical interlocks that interlock any number of circuit breakers, permitting only one to be closed at any one time. His favorite recreations are golf, tennis, badminton, and skiing.

Even though direct strokes are the ones that most frequently cause outages, in determining the probability of a line being struck we must concern ourselves with the total number of storms for any specific area per year since this is the only available data in this connection. W. H. Alexander has published isoceraunic charts showing the frequency of occurrence of thunderstorms throughout the United States. These maps were prepared from United States Weather Bureau records of thunderstorm occurrence at stations scattered over the United States. The records covered a 20-year period. Examination of Alexander's yearly chart shows an average number of about 30 storm days per year for all of this country east of the Rocky Mountains. There are two pronounced centers of activity, the greatest in Florida, with more than 90 storm days; the other in New Mexico with a maximum of 70. The number of storms in the Pacific Coast area is considerably lower, averaging from three to 10. Alexander's monthly charts show minimum storm activity during the month of January with the activity increasing with each succeeding month reaching a maximum for the country in July. The center of storm activity for each month shifts about somewhat but remains pretty much in the south-central and south-eastern part of the country. Although these charts do not give an indication of the intensity, duration, extent, and number of storms occurring, they constitute the best data available. They are of some value in that the relative number of system disturbances recorded per month varies with the months in practically the same manner as the number of storm days per month.

The degree of protection economically justifiable for a given power system depends to a considerable extent on the frequency of occurrence and severity of thunderstorms in the region in which it is located. On the basis of the direct stroke which is now completely accepted for high-voltage lines, protection from lightning can be obtained either with or without shielding. Ground wires are the most widely used form of shielding protection. The object here is to prevent lightning from striking the electrical conductors and establishing an arc path from the line conductor to ground. Instead, the stroke is terminated on the ground wires and is discharged harmlessly to the ground. Protector tubes are one form of non-shielded protection. They do allow an arc to form between the conductors and ground, but possess the ability to quench it without any resulting line interruption. Let us now consider these two types of protection in greater detail.

The "ground wires" or shielding method of protection consists of running strong, non-corrosive wires above and in the same direction as the conductors. As the name implies, the wires are grounded through the tower in the steel tower construction or by means of an additional wire to ground in the wood-pole construction. The selection of ground wires is based on mechanical rather than electrical considerations. Figures 1 and 2 show quite clearly the ground wire arrangement on the transmission line tower. Adequate clearances between ground wires and line conductors must be maintained to the protective voltage level for the particular line. These clearances are maintained by not placing ground wire directly above conductor. In addition to maintaining clearances it tends to keep the tower top cost down. The relation of the ground wire to the conductor is measured by the protective angle (Figure 1) which experience shows should be about 30°. Experience has shown that the probability of side stroke to the tower



Westinghouse Electric and Manufacturing Company

Fig. 1. The relation of the ground wire to the conductor as measured by the protector angle

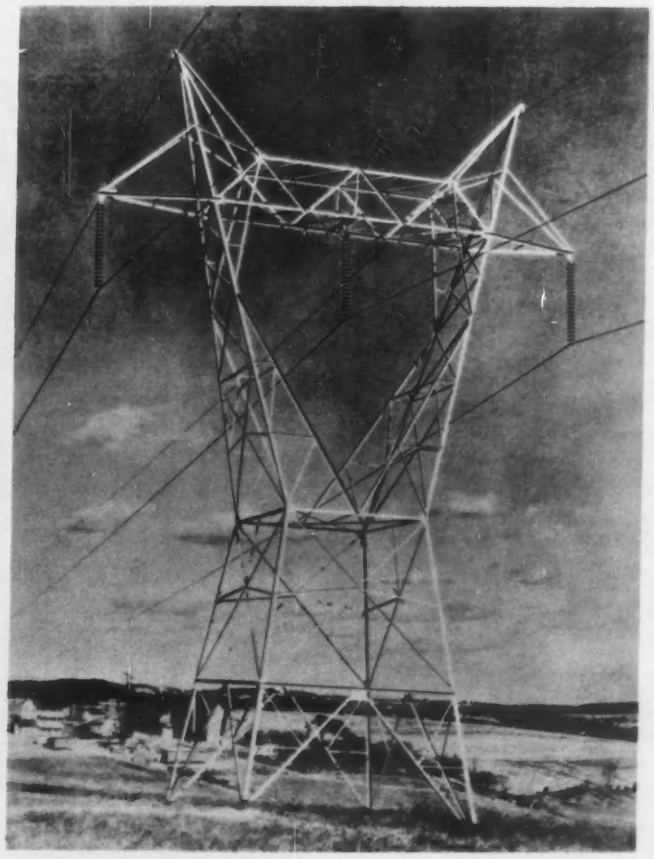


Fig. 2. Actual photograph of tower shown in Fig. 1

Westinghouse Electric and Manufacturing Company

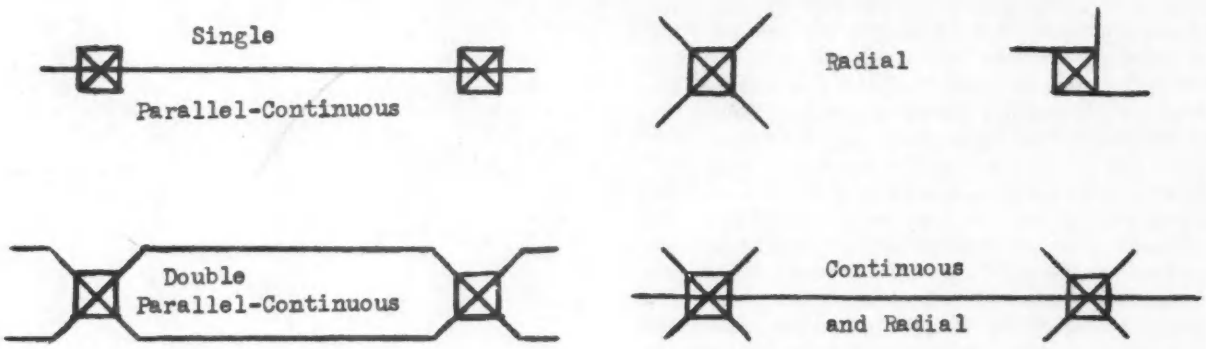


Fig. 3. Arrangement of counterpoises

is very slight. Since the steel tower construction discharges the stroke to ground through the tower it is, therefore, desirable to reduce tower-ground resistance as much as economically possible. With a high tower footing impedance, it would not take a very high current discharge to exceed the flashover voltage of the insulation. The tower-ground resistance is dependent on the type of soil. Chemical treatments have been tried with little success, and are extremely costly. The most successful methods of reducing the tower-ground resistance are by the use of ground rods and counterpoises. Ground rods are merely long slender rods driven into the ground at the foot of the tower and connected to it. Counterpoises are nothing more than conductors buried in the ground, running parallel to or at some angle to the conductors themselves. Figure 3 shows different arrangements of counterpoises.

Figures 4 and 5 show the effectiveness of ground rods and counterpoises. The larger the diameter of the driven rods, the lower the resistance to earth; however, the difference is small, and it is rarely economical to use rods greater than one inch in diameter. The use of parallel ground rods gives lower resistances to ground than isolated rods and the resistance of parallel rods decreases with increase in spacing between the rods. The ground rods are usually driven into the ground at the corners of the tower.

For the same total length of counterpoises, there is not very much difference in resistance to earth whether the arrangement is radial, single-or-double-parallel, or otherwise. There is, however, some advantage in obtaining total counterpoise length by means of a number of short lengths rather than a long one. This will appreciably reduce the initial surge impedance which, in turn, tends to reduce rate of rise of voltage. The resistance to earth with counterpoises decreases with depth but to such a small extent that counterpoises are always placed as close to the surface as is feasible, rarely below three feet.

Wood construction has been used to some extent for towers. The wood insulation plus the insulators increase the overall impulse strength. The manner of grounding a wood-pole line depends on soil conditions and may range from a butt wrap on the pole, to the driving of ground rods, or to some form of counterpoise as for a steel line.

The ground wire is effective for lines with operating voltages above 34.5 kv. where low ground resistances are secured. Clearances on lines constructed for voltages lower than 34.5 kv. are such that flashover may be caused by induced surges from nearby cloud to ground strokes. On the whole induced surges are of lower magnitude than the insulation level on lines for voltages above 34.5 kv. Since ground wires provide no protection against induced surges, the insulation level then becomes a dividing line for use of ground wires. When the induced surges are above the insulation level of the line, some other means of protection must be used. In this case reclosing breakers and de-ion protector tubes are more practical.

The second method of protection, that without shielding, is accomplished more generally by the use of protector tubes. Essentially, it consists of a fiber tube with an electrode in each end, and is applied so that the impulse through it is lower than that of the insulation to be protected. On a transmission tower one tube is often mounted below each conductor so that the upper

(*Continued on page 120*)

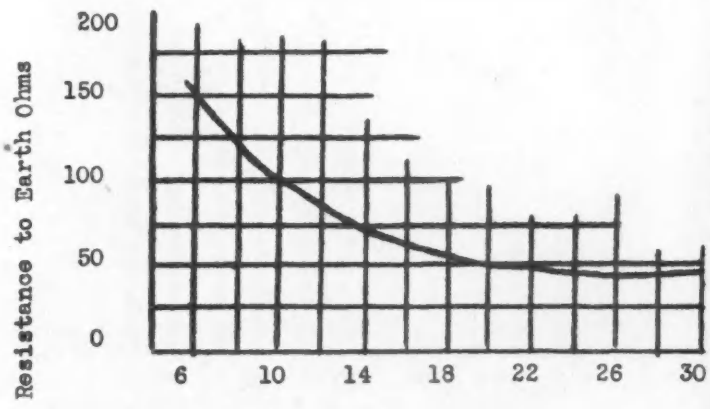


Fig. 4. Driven depth-feet resistance to earth of ¾-inch driven rods

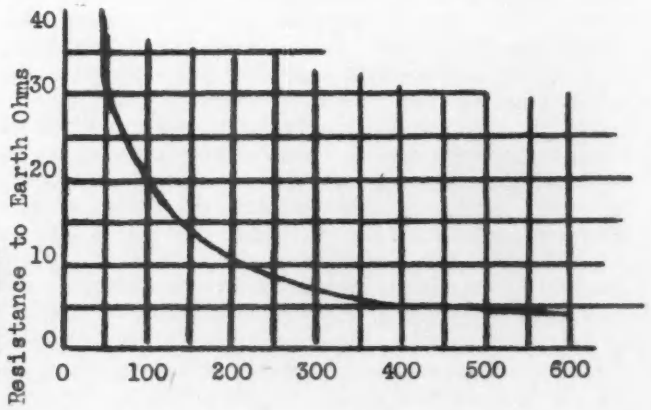


Fig. 5. Length-feet resistance to earth of ⅜-inch single counterpoise at three-foot depth

LIVING OR DEAD

VIRUSES REPRESENT THE TRANSITION FROM LIVING ORGANISMS TO ORDINARY NON-LIVING MATTER

By C. PETER JOHNSON, JR., '45

THE virus is the lowest known type of living organism. Although it is extremely minute, it possesses the cellular structure of the larger one-celled microorganisms. In its ability to reproduce with exceedingly great rapidity in the cells of other organisms the virus resembles other living forms; however, this activity is its only claim to life. It is incapable of motion, and possesses none of the irritability, or response to environment, that characterizes most living beings. Furthermore, unlike other living beings it cannot synthesize its substance from other less complicated materials. It can live and multiply only by destroying the highly complex protoplasmic matter in other living cells. Indeed, the reproduction of viruses is so completely tied up with the destruction of living matter that several investigators believe that the virus phenomenon is simply a degenerative manifestation of the living cells of the virus's host. The virus has a fairly definite chemical composition, particularly in respect to its key substance, its nucleic acid radical. Mutation of viruses, unlike the mutation of higher organisms, involves a small but definitely measurable change in the chemical composition of the cell. For these and several other reasons biologists have concluded that the virus is a single chemical substance. Moreover, the dimensions of the virus are of the same order of magnitude as any protein molecule it could contain. Hence the virus has been tentatively accepted as a single giant molecule. This opinion has been greatly strengthened by photographs of the virus cell under the electron microscope, for no evidence of smaller molecules has been found within the virus. Furthermore, the fact that many species of virus possess an unusual degree of uniformity in their cellular dimensions has given rise to the belief that the molecule in these species has a highly definite structure. Naturally these discoveries have left the biologist quite confused about the exact nature of viruses. Because of their reproductive activity he has been forced to classify them as living, but in practically every other manifestation the virus has indicated that it is simply a protein molecule of high molecular weight. Truly the virus is the borderline between the living and the non-living world.

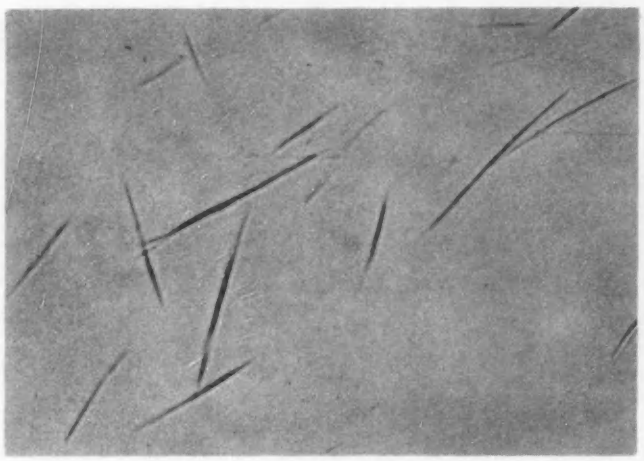
The discovery of viruses has raised the question of whether the concept of life can be a scientific concept at all. Indeed, there is no clean-cut method of distinguishing living matter from non-living. The powers of reproduction, metabolism, growth, and adaptation that are ordinarily associated with life have been found in non-living substances. The phenomenon of growth, for instance, is not peculiar to life; salt crystals will enlarge themselves if they are suspended in a supersaturated salt solution. Moreover, several non-living compounds can synthesize their own substance from foreign matter; for instance, pepsin serves as an autocatalyst in the presence of pepsinogen. Neither is the power of reproduction peculiar to life; Loeb showed that small oil droplets will grow to a certain size and then divide. Moreover, many living organisms lack one or more of the essential qualities of life. Many show practically no metabolism, and practically no power of adaptation. With the virus the conflict between various classifications of life becomes highly evident. Even today biologists are not agreed as to whether viruses are living. All that one can say of the virus is that it possesses certain qualities, like apparent reproduction, and that it lacks others, like response to environment.

Peter Johnson is a sophomore studying chemistry at M. I. T., and an associated editor of The Tech Engineering News. *Although born in Montclair, New Jersey, he has lived most of his life in Washington, D. C., and in Coral Gables, Florida. Johnson is a member of the M. I. T. Chemical Society and the American Chemical Society. Last year he received the Alpha Chi Sigma freshman chemistry award. This is his third article in the magazine.*

Viruses are responsible for many of the commonest diseases that afflict animals and plants. The most completely studied plant virus disease has been the tobacco mosaic disease, for the tobacco mosaic virus is easily cultured, purified, and studied. The virus diseases that afflict the higher animals are, however, more familiar to the average man. They include several mild diseases like the common cold. However, several of the most dangerous diseases known are caused by viruses. Rabies, distemper, smallpox, infantile paralysis, and spinal meningitis have been traced to viruses. In addition, several types of cancer, of which a type of chicken tumor is one of the best examples, have been found to be associated with virus activity.

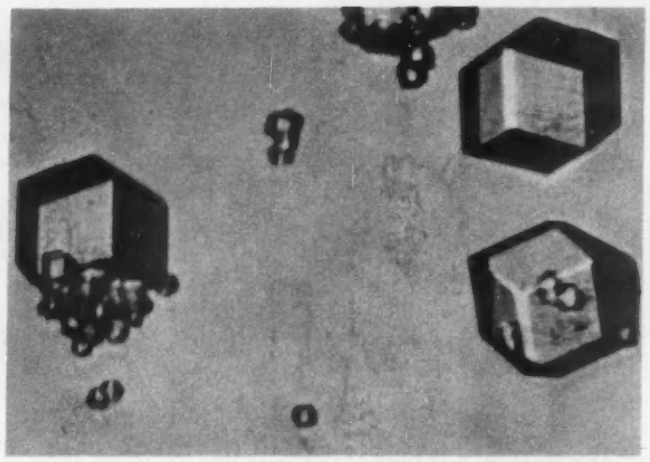
Viruses were discovered very near the end of the nineteenth century. It was discovered that the extracts from organisms infected with certain diseases could cause infection of other living beings. At once the presence of microörganisms was suspected in the extract, but examination of the fluid under even the most powerful microscope showed no evidence of cells. Furthermore, the toxic extract could pass through the pores of filters impermeable to ordinary microörganisms without losing its activity. Although this filterability indicated the presence of a toxin rather than of microorganisms, the rapid multiplication of the disease-producing material in a living body showed the presence of living matter, and the presence of extremely small living particles, named viruses, was postulated.

Early in the twentieth century viruses were isolated by salting them out of solution. Various other means, such as the adsorption of viruses on certain minerals,



W. M. Stanley and the Journal of Biological Chemistry

Fig. 1. Needle-like crystals of the tobacco mosaic virus (Magnified 675 times)



W. M. Stanley and the Journal of Biological Chemistry

Fig. 2. Crystals of the tomato bushy stunt virus (Magnified 225 times)

then were used to isolate a large variety of virus strains. However, since it was found that the somewhat drastic chemical action impairs the activity of the viruses, there have been developed in recent years a variety of ways of separating viruses from other materials by means of electric fields and differential ultracentrifuging. These processes have afforded a satisfactory separation of many plant viruses, but animal viruses are always found with a large amount of matter of approximately the same molecular weight as the virus, from which the virus cannot easily be separated. For this reason the important research on viruses has been done almost entirely with the varieties that infect plants.

Within recent years a startling advance was given to virus biology by Stanley's crystallization of the protein matter of the tobacco mosaic virus by means of salt and acid. Because of its crystalline nature this substance was looked upon as a definite compound. The crystallized protein, like non-living matter, can apparently be kept indefinitely without decomposition or inactivation. However, if the crystals are put in contact with living cells, the protein changes to the normal form of the virus and exhibits all of the characteristics of the original virus. Thus the active and the inactive forms of the virus seem to be forms of living and non-living matter respectively.

Much work has been done recently to determine the sizes and shapes of the various kinds of viruses. By means of measurements of viscosity, sedimentation, and several optical properties of virus suspensions the dimensions of several viruses were calculated, and the tobacco mosaic virus was found to be a rod-shaped particle about 500 millimicrons (millionths of a millimeter) long and 15 millimicrons wide. When the electron microscope was invented, it was soon used on viruses, and it was discovered that the tobacco mosaic virus is 330 millimicrons long and 15 millimicrons wide. From these dimensions the molecular weight of the virus has been estimated to be 50,000,000, indeed that of a giant molecule.

Soon after the isolation of the viruses chemical analyses were run on the microörganisms. The analyses showed that the viruses contained a reasonable amount of carbon, a large percentage of nitrogen, and a trace of phosphorus and sulfur. The large percentage of nitrogen pointed conclusively toward protein matter. The small amount of phosphorus, however, was neglected, and erroneous conclusions were reached concerning the nature of the protein. Finally Bawdin advanced a theory that the virus was a nucleoprotein, consisting of a small amount of nucleic acid and a very large excess of

(*Continued on page 123*)

Fig. 3. An electron photomicrograph of the individual tobacco mosaic virus molecules. (Magnified 35,000 times)

W. M. Stanley and the Journal of Biological Chemistry

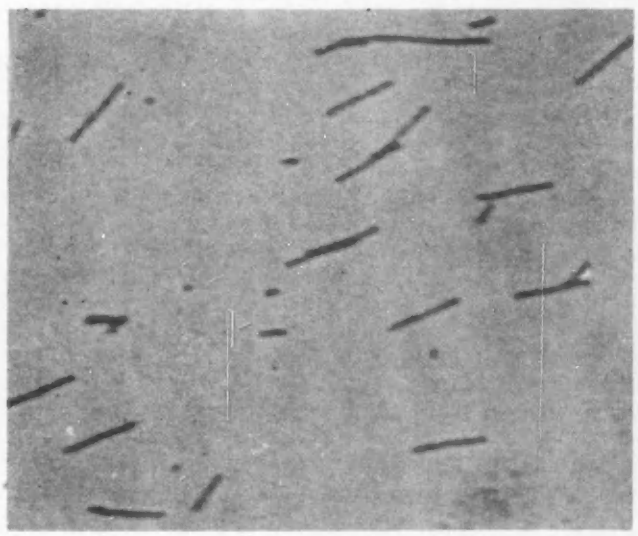
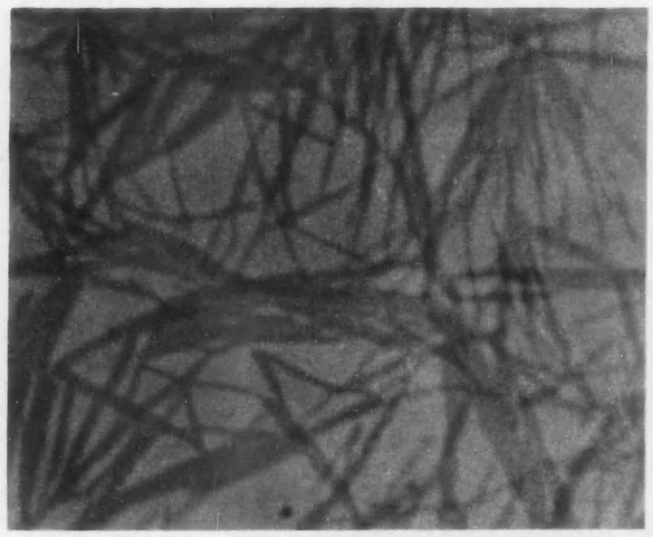


Fig. 4. An electron photomicrograph of the tobacco mosaic virus, showing the tendency of the virus molecules to aggregate to form long strands. (Magnified 51,300 times)

Courtesy of the Department of Biology, M.I.T.



NEWS ON THE WIRES

THE TELETYPEWRITER AND THE TELEPHOTO SPEED THE DISTRIBUTION OF WARTIME NEWS

By CARROLL W. BOYCE '45

THE teletypewriter and telephoto are two of the newest instruments for the transmission of news, both by wire and radio signal. Both of these machines are so new that their entire field of usefulness has not been realized at the present time, yet it is a fact that the printing telegraph, the prototype of the teletypewriter, is almost as old as the telegraph itself. The reasons for the printing telegraph's early invention, yet slow development, become apparent only after the advancement of the whole science of telegraphy and the demand for its services have been considered. The wirephoto, on the other hand, is a refinement of telegraphy which necessarily had to wait for the development of a photo-electric cell.

Since telegraphy merely consists of a means by which electrical signals may be transmitted from one point to another, the speed and accuracy with which these signals could be translated into words (and later pictures) determined its success as a means of communication. Under the old manual system one mediocre operator anywhere along the line could materially reduce its efficiency, so it was only natural that inventors and scientists should be attracted to the problem of devising a mechanical means for the conversion of letters into signals and vice-versa.

The first record in America of an apparatus designed to perform this function appeared in 1846 when Mr. Royal E. House applied for a patent on a "printing telegraph." Coming, as it did, just two years after the first telegraph message had been transmitted, it was called for solely because of the lack of well trained Morse operators. As the regular typewriter keyboard was not in use at that time, the House machine employed a piano keyboard of twenty-eight keys, one for each letter of the alphabet, one for a dash and one for a dot. The keys, when pressed, locked in corresponding pins set in a revolving cylinder. At the end of the cylinder, placed opposite each pin was a metal plate forming contact with the telegraph line and closing the circuit. The locking pins on the cylinder were so placed that the key for each letter would lock only after the cylinder had passed through a certain portion of a turn. As a result, the number of times the circuit would be closed varied with each key. Each contact with the line actuated an electro-magnet at the receiving end; and this operated the piston of a compressed air cylinder which turned a type wheel. Thus the letter finally printed was determined by the number of impulses transmitted over the line.

However, the lack of success in the commercial field of the House machine forced development along new lines. Its use had proved that to be adaptable to commercial use, an automatic translating transmitter and receiver must not only produce the desired mechanical results but be economical as to machine and line costs,

Carroll Wilson Boyce, a sophomore in M. I. T.'s co-operative course in Electrical Engineering, is the Editorial Editor of THE TECH ENGINEERING NEWS. *A Dean's list student, he prepared at the Milne and Mamaroneck High Schools, where he was editor of the weekly paper. He is a member of the Alpha Tau Omega fraternity. This is his second article in* THE TECH ENGINEERING NEWS.

be faster than the Morse machine, be portable, and relatively easy to maintain.

The next important step was Wheatstone's perforating telegraph: a tape perforator (in no way connected with the line), an automatic transmitter, and a tape recording receiver. The message was perforated on the tape in Continental code; the tape was fed through the transmitter which sent out signals regulated by the perforations; and at the receiving end another tape became similarly perforated. This method increased both the readability of messages and the transmission speed, thus effecting huge economies for the operating companies. Its one great disadvantage was that rather than decreasing the total time between sending and receiving a message, including the time for coding and decoding, the period was increased.

It was in 1875 that Jean Baudot, a Frenchman, gathered the best elements of the forty-odd telegraph printers which had appeared up to that time and put together a device which was the real beginning of the teletypewriter of today. The chief reason for the success of the Baudot machine was that it employed an equal letter code for the transmission of signals, the shortest possible code, and was easily adaptable to simple printing mechanisms. The length of letter and symbol combination in previous codes, which were all based on the dot, dash and space, had varied from one to thirty time units. The code Baudot adopted made use only of the current and no current signal. These were combined in groups of five, thus making possible thirty-two combinations, providing a separate signal for each of the letters in the alphabet and six others for special use, all of the same time length.

Both of the teletypewriter systems in use today, the "Multiplex" and the "Start-Stop," make use of the methods developed by Baudot. The most important features of each of these instruments are the transmitting and receiving distributors, extremely simple devices. These distributors, at either end, consist of two concentric rings. The outer ring is divided into five segments, corresponding to the five units of the Baudot machine. As a key on the typewriter is depressed, the proper condition of current or no current is established on each of the segments of the ring. A revolving brush driven by a motor passes over these rings, and as it

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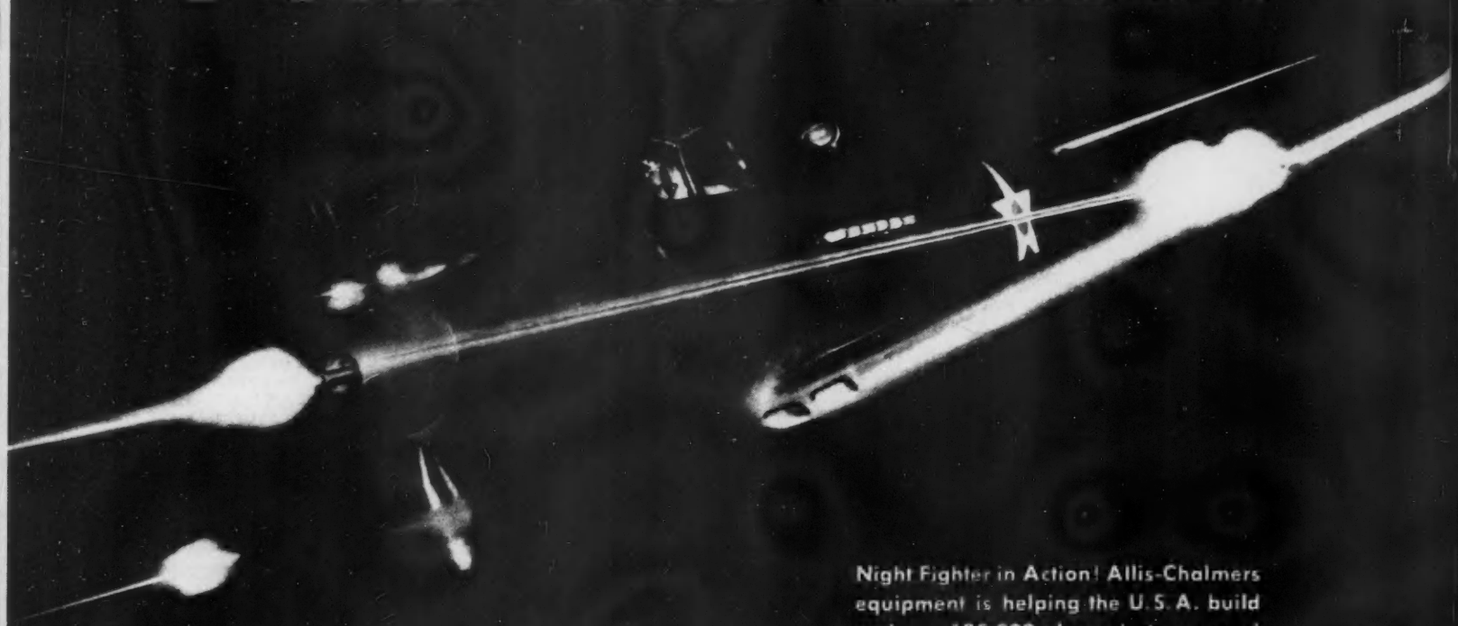

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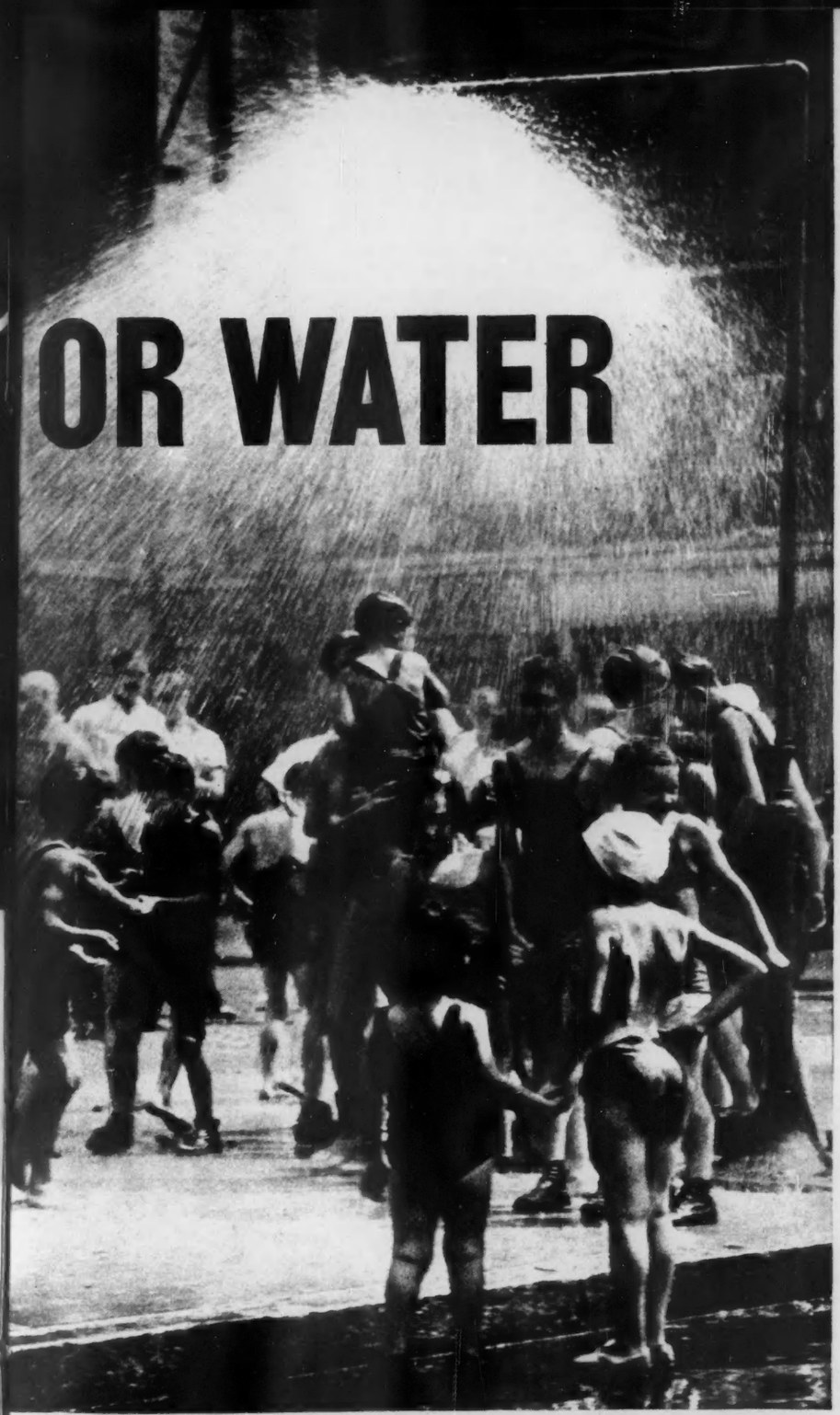

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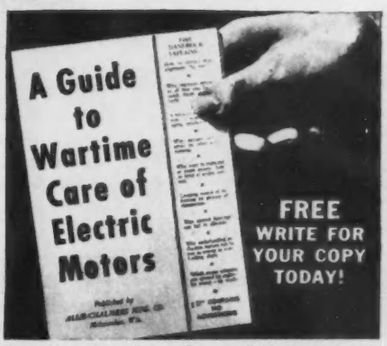

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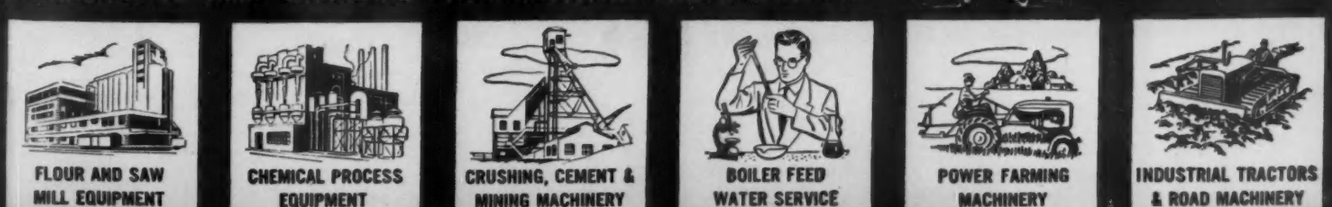
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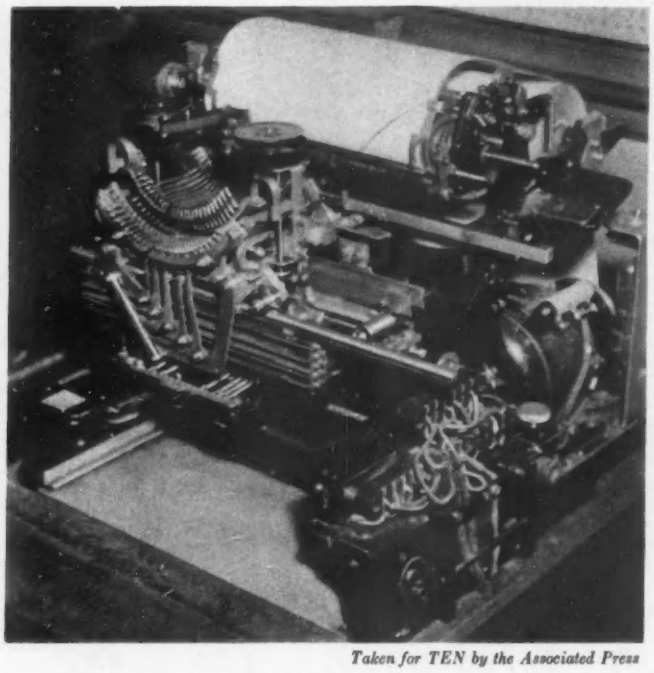


Taken for TEN by the Associated Press

Fig. 1. Teletypewriter receiving apparatus in action at the wire room of the Boston Globe. The metal case has been removed

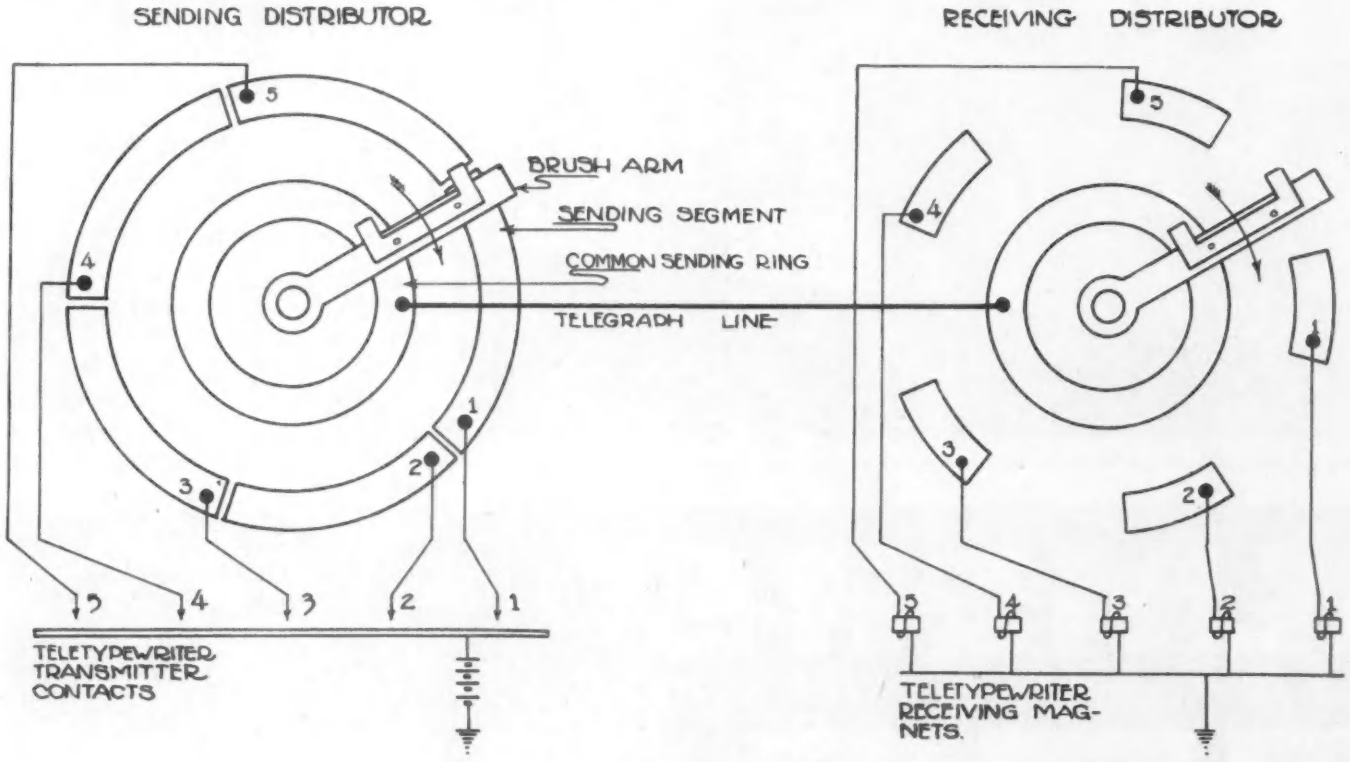
travels over the outer ring, it picks up the proper current signal from the various segments and communicates it to the inner ring, which is connected to the line. At the receiving end there is a similar arrangement with a brush rotating in synchronism with the one at the transmitting end. This brush, being connected to the line, transmits to the segments of the outer ring the same signal impulses that are set up at the transmitting end. Selecting relays are connected to the five segments at the receiving distributor which operate five bars in different combinations. Each of these combinations will release but one type bar, which prints the required letter. (See Figures 1 and 2 for picture and diagrams.)

The problem of synchronization has been the reason for the division of the original Baudot into two separate systems in accordance with the demand for their use. Where there are only two stations on the circuit, which is an uncommon occurrence in these days of vast networks, the distributors can be kept in phase by the use of speed correcting selecting code impulses without losing any speed, but where there are many stations on the circuit, it is practically impossible to maintain all the machines in perfect synchronism. Therefore, the "Multiplex" or continuously synchronized system is almost exclusively used by the telegraph companies which dispatch large volumes of traffic from point to point.

As there has been an increasing demand for teletypewriters able to operate with a great many stations on the line, the "Start-Stop" machine has been developed to adapt teletypewriters for this purpose. This machine sacrifices some of the speed of the "Multiplex" to gain in flexibility. The transmitting and receiving mechanisms are restrained from operating by a device which is released when the first impulses are sent. In order to accomplish this starting function, the five selecting signal elements are preceeded by a signal element of opposite current value from that of the line in idle condition. A seventh concluding signal is transmitted which locks the machine until the next character is ready to be sent. Therefore, the sending and receiving are required to remain in synchronism for only one printing cycle. The teletypewriters are usually arranged to type at the rate of sixty words per minute; so with the duration of one printing cycle being only about one-sixth of a second it is possible to accomplish synchronism without rigid requirements on the speed of the motors. It is machines of this "Start-Stop" type which are used for the nationwide teletypewriter networks of the press associations.

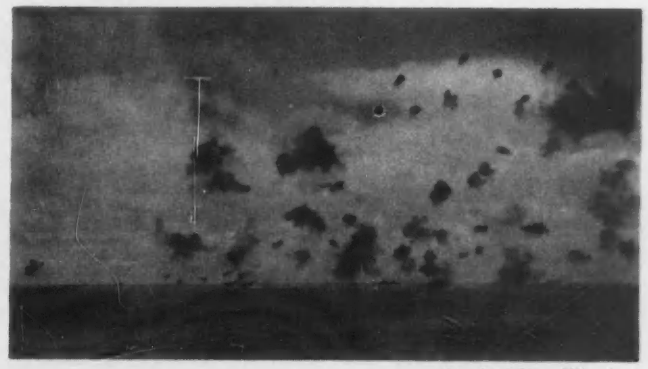
The most extensive use of the teletype is undoubt-

Fig. 2. Principle of teletype distributor operator



The Associated Press

Fig. 3. A picture being prepared for transmission over the wirephoto network. In the background is the control board



Associated Press Wirephoto

Fig. 4. The picture is a good example of modern wirephoto transmission. It shows the aircraft carrier Yorktown throwing up an umbrella of fire during the Battle of Midway.

edly for the distribution of news, but more and more use is being made of it today by police organizations, financial houses, aviation companies, the Weather Bureau, and the Armed Services. Its value to the Army has been considerably enhanced by the introduction of a refinement which permits the order in which the impulses are transmitted to be rearranged by means of "filtering" them through a perforated tape. The signals thus sent can be unscrambled only by a machine which is equipped with an exact duplicate of the codifying tape, so that interception by the enemy will not yield an intelligible message, and yet the transmission and reception are both in a non-code form.

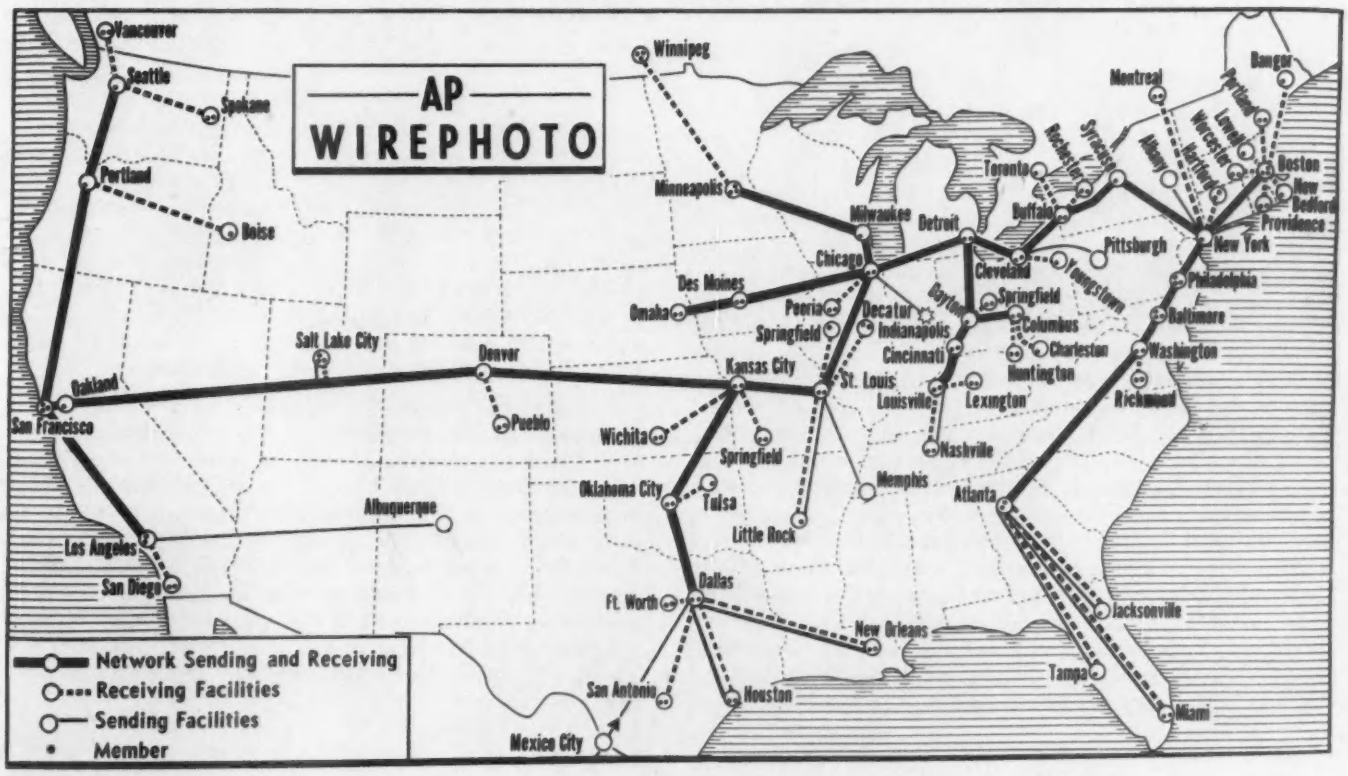
With the increased commercial demand for teletypewriter service it has become necessary to set up a system for giving nationwide teletype service on much the same basis as telephone service. By the establishment of switching centers at various points it has become possible for any of the many subscribers to contact any other subscriber on a two-way circuit.

Just as the teletype solved the problem of rapid transmission of news, so the telephoto is solving the problem of providing pictures which are in time-phase with the news. Ever since the development of the photo-engraving process, newspapers have been searching for faster and faster methods of bringing pictures to their readers. The airplane made possible a considerable speed-up, but the lag was still many hours and perhaps even days, so that pictures were no longer fresh when they reached the public. The search for a means of electrical transmission of pictures was stalled until after the invention of the photo-electric cell. (For a story of its development and other applications of the photo-electric cell see "The Invisible Policeman" in THE TECH ENGINEERING NEWS, April 1942.)

Various developments were tried and rejected because of the poor quality of reproduction. Then, from the Bell Laboratories, came the system that is now known as Wirephoto, and arrangements were soon made for the non-profit Associated Press to take over the mechanism, which now may be operated over any ordinary telephone line, although stations on the regular

(*Continued on page 124*)

Fig. 5. This vast network has been developed entirely since the inauguration of Wirephoto in 1935



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FRANKLY SPEAKING...

DUAL-PURPOSE EDUCATION

Since the beginning of the war America's educational system, particularly on the university level, has undergone many changes, and the revision is bound to continue as time goes on. With the ever-growing need both by the Army and industry for trained engineers and technicians, the educational emphasis has shifted markedly to engineering and research training. While the necessity of this transition is recognized in all quarters, it must be realized that the change cannot, and should not, be complete. While it may, on the surface, seem to be desirable to equip students with the greatest amount of technical knowledge possible in the shortest possible time, it should be remembered that even in wartime life is not all just formulae and test tubes, pluses and minuses, but is still basically a relationship of human beings, singularly and collectively. To this end it is imperative that the student should be prepared to conduct himself properly not only in the research laboratory or behind the engineer's desk, but also in the larger world of living people. Thus it would appear that the ideal education, the one which can produce the man who will be of the greatest worth to himself and to humanity, is that which combines some study of the social sciences, and, if possible, of languages and the arts, with a sound technical training. Of course, the balance of these educational constituents must be determined largely by the pressure of the times, and right now the scale swings heavily toward technical training. Even though engineering may be the crying need of the present hour, when one remembers that the students of today are the business men and leaders of tomorrow, it drives home the fact that they must be prepared to fill their place in the society of the future. Thus, then, it is seen that our present program of dual-purpose wartime education, preparation of the soldiers of today and citizens of tomorrow, can be brought to its logical conclusion only by offering students a carefully planned combination of technical and social studies.

From an undergraduate point of view, the present curriculum at M. I. T. appears to strike just such a balance, in the proper proportions to be consistent with the urgency of the war period. Depending upon the student's course, between eighty and ninety per cent of his undergraduate work is devoted to technical courses, the remainder being given over to studies of English, languages, psychology, industrial relations and their allied subjects, and the fine arts. The volume of undergraduate work, as called for by the schedules, averages about fifty-five hours a week, this representing very nearly the industrially determined maximum at which a man can operate at peak efficiency, and yet leaves enough free time for participation in personally broadening social and extra-curricular activities.

As the war progresses the time may come when the present technical program will have to be stepped up, and if it does the students will be ready to coöperate in any way necessary to hasten victory. But until peace is restored and it becomes possible to incorporate an even larger percentage of non-technical subjects than now, the present balance of scholastic organization at Technology would seem to offer the best possibility of producing engineers who will not only mature soon enough to be of value in the war effort, but who will also be equipped to fill their rightful place in our post-war society.

Every branch of the Armed Services uses the telephone. No. 2 of a series, Submarine.

Five thousand miles from home Bill — Torpedoman — is keeping a date. Weeks of waiting, days of watching, hours of hiding under the sea, all for the moment when he reports over his wartime telephone, "All tubes ready, sir!" There'll be other dates, Bill — better ones — in the kind of world you're fighting for.

Western Electric

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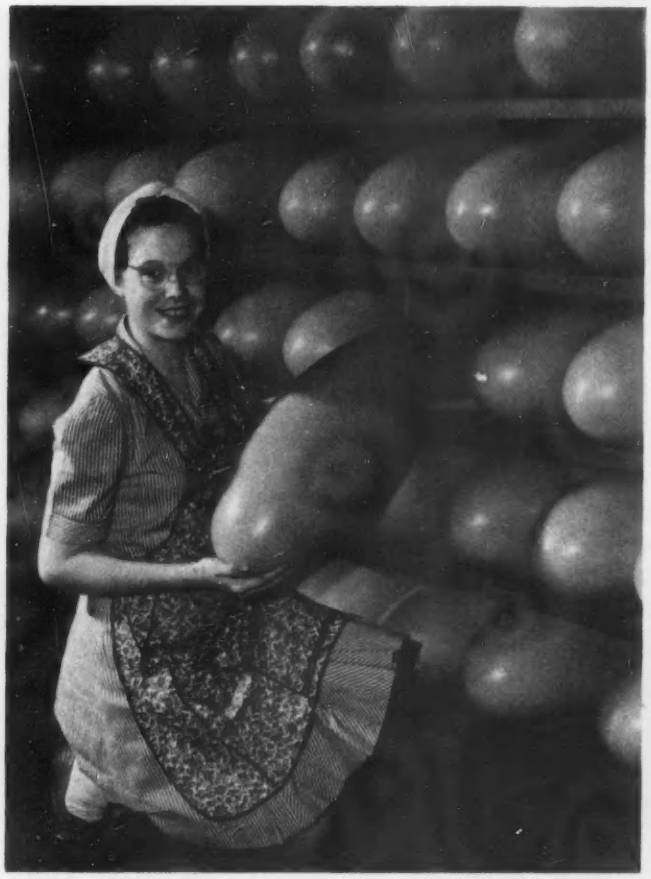

General Electric Company

Removing one of the radio antenna housings from its rack to demonstrate its lightness

BRIEFING THE NEWS...

PLASTICS GROW UP

Wartime military uses are demonstrating that plastics can no longer be considered merely as substitutes for metal, but that through their own valuable properties they are performing many tasks better than previously used materials. Plastics are taking their place on the warfronts of the world — in helmet liners, gas mask deflectors, bayonet handles, gun control mechanisms, trench-mortar fuse caps (see pictures), in firing pins for anti-aircraft gun shells, and in torpedo detonators. Today one battleship requires over a thousand plastic parts. Landing barges, torpedo boats, training planes, and invasion gliders are constructed of

(Continued on page 118)

Plastic fuse cap for 61 mm. mortar *U. S. Army*

Using new gages to assure perfect measurements of the trench-mortar fuse caps *General Electric Company*

Trench-mortar shell, showing plastic fuse cap detached

General Electric Company

The **TECO** *Ring Connector spreads the load on a timber joint over practically the entire cross-section of the wood . . . brings the full structural strength of lumber into play.*

New Navy Blimp Hangar, 1000 feet long; 153 feet high; clear-span roof 237 feet. Timber treated for fire resistance according to Federal specifications. Trusses prefabricated by Timber Structures, Inc., Portland, Oregon.

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WASHINGTON, D. C. PORTLAND, OREGON

OUR NAVY BUILDS WORLD'S GREATEST TIMBER STRUCTURE

mammoth blimp hangar was made possible by

TECO CONNECTOR ENGINEERING

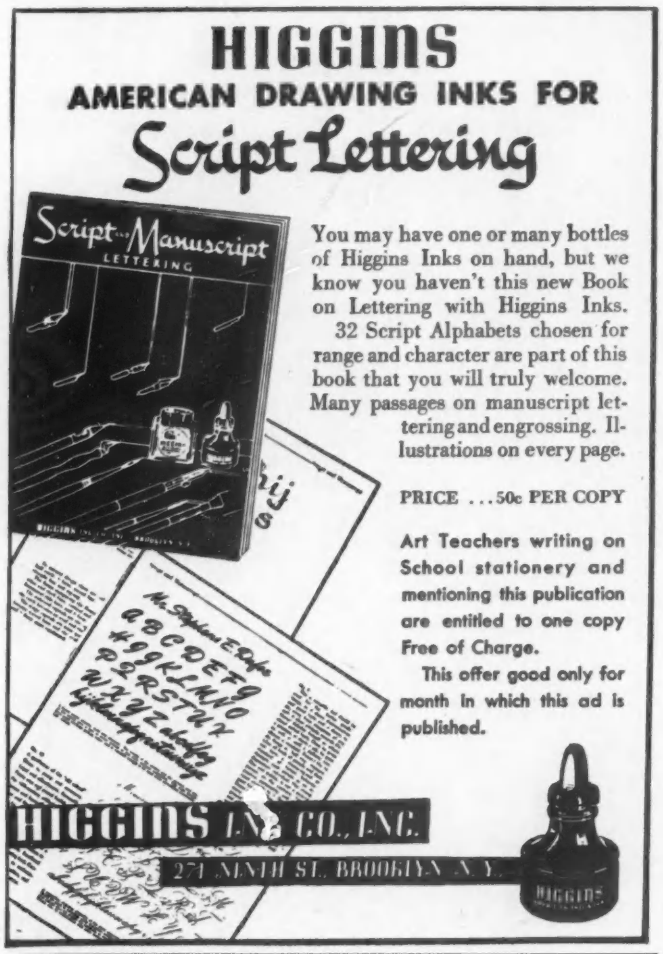
Two announcements of the widest import to American engineering have just come out of Washington.

The U. S. Navy has announced that a giant blimp hangar, engineered entirely in timber, is nearing completion "somewhere in the continental United States."

The War Production Board has announced that "such a structure could not have been built of wood by ordinary methods without the use of timber connectors . . . The steel ring timber connector, which is used to increase the strength of joints in wood construction, saved more than 400,000 tons of steel for essential war production in 1942." WPB added that 2,050 tons of structural steel will be saved in this hangar alone.

In erecting this vast, multiple-truss assembly, Navy engineers have accomplished a notable achievement in modern timber connector engineering. The hangar is the latest of scores of large Navy, Army, and Maritime Commission projects built with Teco timber connectors under the revolutionary Teco system of timber engineering. It is one of *over 100,000* heavy-duty structures, of *over 600* types, built under the Teco connector system in the past few years. They include clear-span factories, bridges and trestles, towers, tanks, warehouses, docks, shipyards, and many others.

Write today for our FREE Reference Book for engineers and architects showing 45 *"Typical Designs of Timber Structures."*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BRIEFING THE NEWS ...

(*Continued from page 116*)

plastic-bonded plywood. Typical of the many important plastic products of the war were the tear-shaped loop-antenna housings installed in each of the B-25 medium bombers that General Doolittle led over Tokio last year.

Especially new to the industry are the heavy, abusive uses to which plastics are currently being adopted. Many of our latest vessels will soon have plastic drive shaft bearings, which are expected to wear longer than metal bearings. Plastic rayon-spinning buckets, operating at 10,000 r.p.m., are used every hour of the day in contact with acid and salt solutions and yet have an average life of four and one-half years. There is now even a special plastic that withstands the deteriorating effects of high-octane aviation gasoline. These major roles point the way to an even greater post-war importance of plastics.

A sodium lamp being used for microscopic inspection to detect possible flaws in small metal parts

General Electric Company

SODIUM LIGHT IN INDUSTRY

While the sodium lights on many of the nation's highways have been extinguished in dimouts for the duration, the familiar yellow arc light is being used in numerous war plants for microscopic surface inspection of materials. The monochromatic nature of this light permits the eye to observe cracks and flaws without loss of detail due to chromatic aberration. Sodium light, furthermore, is very near the yellow-green region of the spectrum, where maximum eye sensitivity occurs.

Sodium lighting for microscopic inspection has been found most effective when the light is spread uniformly over a large area. In this way, an undistorted view of the magnitude of flaws is obtained. Also the level of the illuminating source should be fairly high to provide maximum contrast between flaws and surrounding surfaces, and all sunlight should be excluded to preserve the monochromatic properties of the light.

When looking for cracks and blow-holes it has been found helpful to treat surfaces with either a light-absorbing or a light-reflecting dye, depending upon the surface in question. This increases the contrast to a point where the most minute blemish can be detected.

OUR ENEMIES' EXPLOSIVE INCENDIARIES

Germany's one kilogram magnesium incendiary used so destructively in the early part of the war and up until the late summer of 1942 is now being supplemented by a similar bomb containing a high explosive charge. The tactical purpose of the bomb is still to start fires, but the high explosive hastens this end by spreading the kindling material over a wider area, thereby multiplying its potentialities and adding to the difficulty of control.

In addition to the one kilogram bomb, the Germans have also developed a fifty kilogram high-explosive incendiary. This expels sixty small thermit containers and six larger, preignited magnesium firepots. The bomb has an explosive charge of twelve pounds of TNT. Fifty kilogram phosphorus incendiaries which scatter spontaneously igniting phosphorus have also been recently dropped by the Germans.

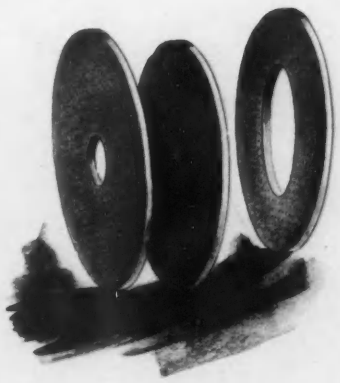
The Japanese have been perfecting their incendiaries too. They now have a one kilogram red phosphorus bomb containing an explosive tube of picric acid which detonates on impact, spreading the casing and burning phosphorus over a fifty-yard radius with shrapnel effect. Another Jap bomb weighing fifty kilograms contains rubber pellets impregnated with red phosphorus. Upon drying, each of these pellets can cause a small fire of five or ten minutes duration. A sixty kilogram thermit incendiary containing three inserts which are scattered by an explosive charge to act as separate incendiaries and a solid oil bomb with a central tube filled with thermit and quick match have also been developed by the Japanese.

These bombs quite revolutionize extinguishing methods formerly recommended and, in general, require additional protection for the firefighter. A stream or jet of water, instead of sand, is advised for control of these new types. For his own safety, however, the operator should place himself behind a solid wall equivalent to four and one-half inches of concrete, instead of behind improvised barricades, such as overturned davenports, previously recommended.

This Merry-go-round has gone to war!

1. It takes a lot of parts to make a Jeep. And this "merry-go-round" has the job of grinding some of those parts (those with flat surfaces)...in a hurry! By rotating a large number of pieces beneath a Carborundum made disc wheel, it surface grinds them in a fraction of the time required by older methods. This process is one which Carborundum helped develop.

2. Surface ground parts for jeeps, tanks and other weapons just couldn't be finished one at a time; production would be hopelessly low. The introduction of disc wheels and the "merry-go-round" surface grinder put surface grinding on a real mass production basis. The method can be used to generate flat surfaces to precision tolerances, on smallest pieces or on massive forgings and castings. It speeds production of many vital war items from valve springs to connecting rods, from piston rings to clutch plates!



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FOR Victory AND AFTER

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Simplex Wire & Cable Co.
79 Sidney Street, Cambridge, Mass.

THOR VS. KILOWATTS

(*Continued from page 106*)

electrode is connected to an arc-shaped horn located the proper distance below the conductor, thus forming a series gap with the conductor. Figure 6 shows a typical application of the tube. When a surge appears on the conductor, the series gap is broken down and an arc is formed in the tube between the electrodes. The heat of the arc vaporizes some of the fiber of the tube walls, expelling a neutral gas violently into the arc stream. This sufficiently de-ionizes the arc to prevent its restriking after the first zero point of the 60-cycle power current. Figure 7 shows operation of the protector tube. The tube must be capable of interrupting the generated follow current. After the surge currents are discharged to ground, the normal frequency or generated current flow may follow. So that for satisfactory operation, the protector tube must recover its insulation strength after generated current zero faster than the system voltage rises.

Theoretically, for nearly complete protection against lightning strokes a protector tube should be installed on every tower. This, however, is very seldom done, because the economics of such an application would not warrant it. The location of the protector tubes depends on a number of factors, such as ground resistance, line insulation, and frequency of storms. The distance between tubes then becomes a compromise between the economics of these factors.

Another method of protection against lightning surges is by means of a Petersen Coil. It is a reactance coil connected between the system neutral and ground.

(*Continued on page 123*)

Fig. 6. Application of the protector tube
Westinghouse Electric and Manufacturing Company

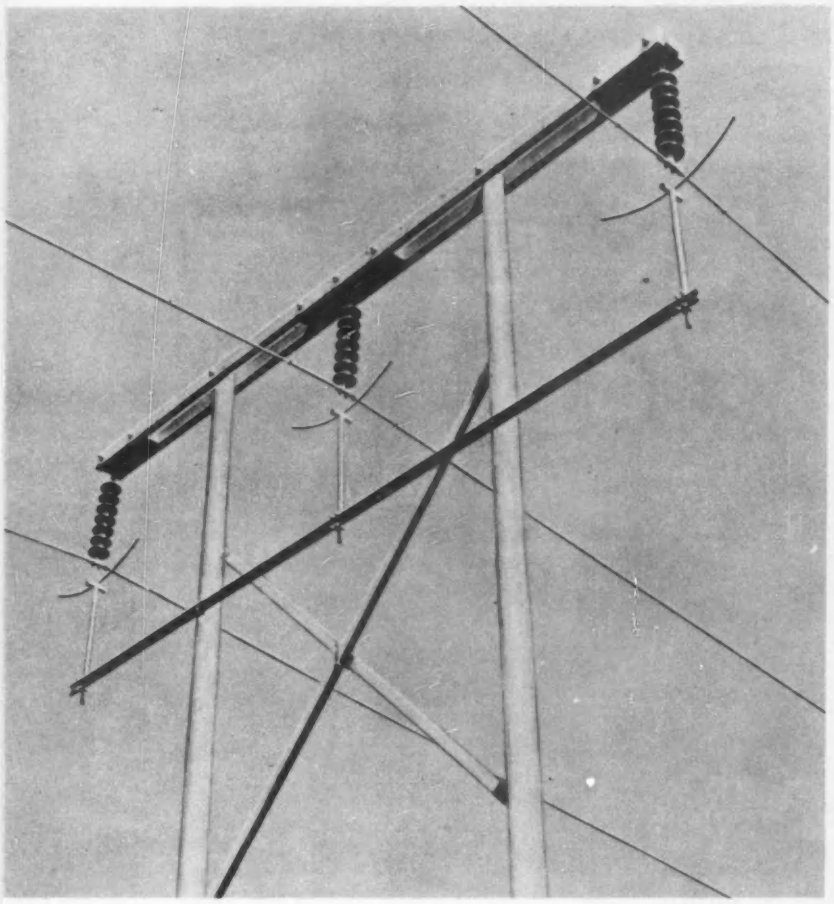
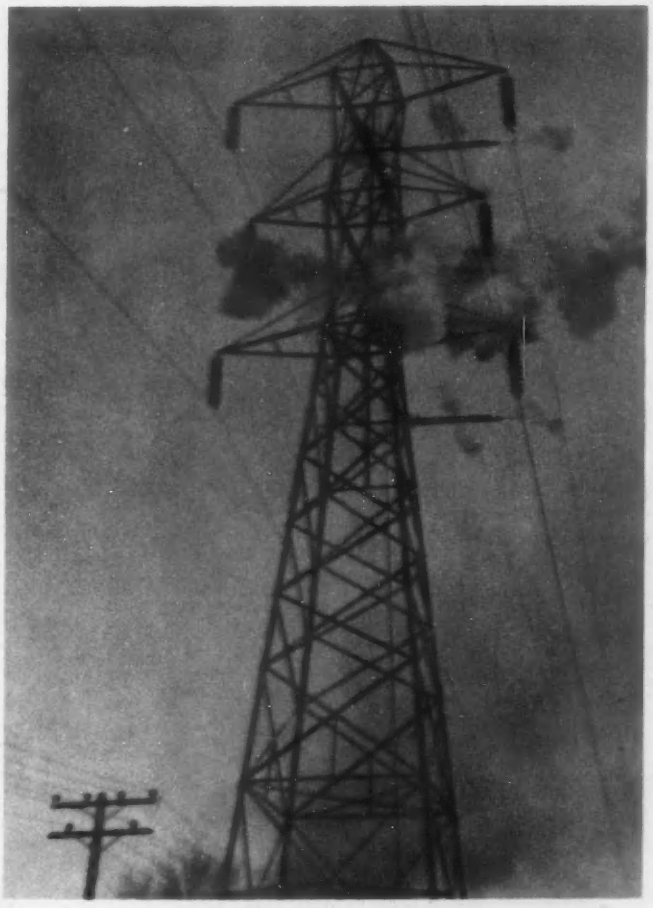


Fig. 7. Operation of the protector tube
Westinghouse Electric and Manufacturing Company



The Goblin that works for America

THE INQUISITIVE alchemists of the Middle Ages were looking for silver. Repeatedly, they smelted certain ores and got a silvery-looking metal. But it was only *silvery-looking*. It never turned out to be silver. So the alchemists thought that a malicious spirit was thwarting them, and they called the strange metal Kobold, meaning goblin.

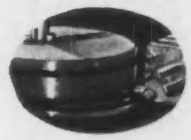
Today that same goblin, known in America as cobalt, has become one of this country's great fighting elements. Cobalt is alloyed with chromium and tungsten to make "Haynes Stellite" alloys which have the property of "red hardness." Metal-cutting tools made of these alloys keep on cutting even when red hot! Cobalt improves red hardness and toughness in other kinds of metal-cutting tools. Thus, cobalt has contributed greatly to the tremendous output of planes, tanks, guns, and other war materials.

Cobalt is also used to produce improved magnet steels. Permanent magnets of cobalt-tungsten steel are more powerful, and last longer. Permanent magnets are necessary in much electrical equipment.

This country's cobalt formerly came from Belgium, where it was refined from African ores found in the Belgian Congo.

As war clouds loomed, and as accelerated American industry made rapid inroads on the stockpiles shipped out of Belgium during 1938 and 1939, ELECTRO METALLURGICAL COMPANY, a unit of UCC, designed and built facilities in this country for the Belgians. ELECTROMET now operates these facilities so that HAYNES STELLITE COMPANY, another Unit of UCC, and other American companies can have the cobalt they need for essential war work. Operations began in 1941. Today, these facilities annually produce more cobalt than was ever imported in any year previously.

BUY UNITED STATES WAR BONDS AND STAMPS



RED HOT... STILL CUTTING! Faster production of metal equipment of all kinds is made possible by high-speed metal-cutting tools containing cobalt.

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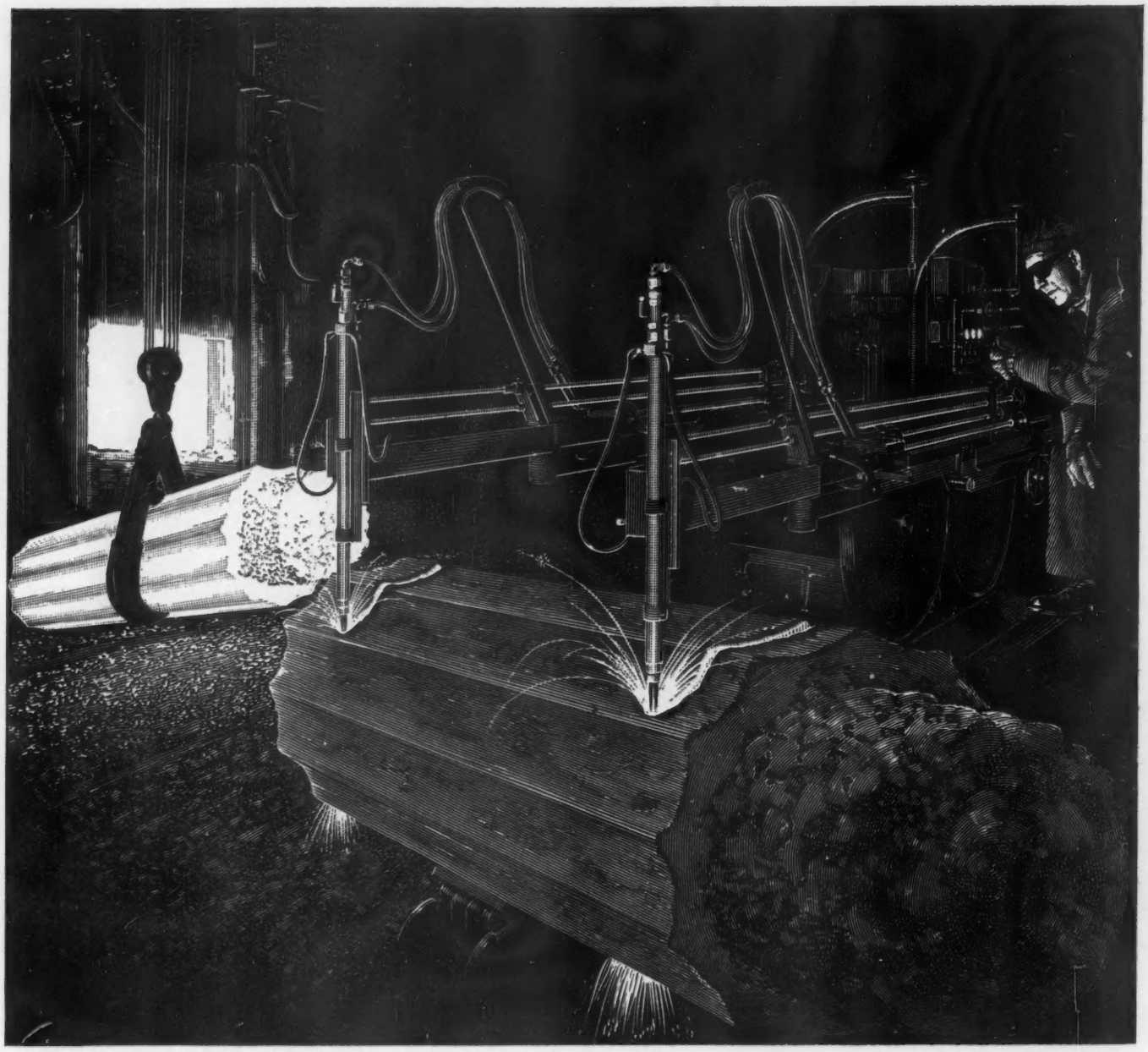

A quick trim for a metal giant

MAMMOTH ingots of steel for war weapons must be "cropped" or trimmed at the ends before forging. Formerly this job was done slowly and laboriously on a heavy press, but today the huge ingots are sliced neatly and quickly by the oxyacetylene flame.

Using a new heavy cutting technique developed by Airco Research Engineers and cutting through metal as thick as 36", the oxyacetylene flame trims off both ends of this ingot at once in approximately 11 minutes, compared to several hours required by other methods. The new ingot cutting machine designed and built by Airco engineers especially for this job guides the movement of the oxyacetylene cutting torches in an arc corresponding to the ingot contour.

This new flame cutting application typifies the ever-expanding usefulness of the oxyacetylene flame in American industry. Spurred by the need for swifter war production, industries are finding more and more ways to accelerate manufacturing with oxyacetylene flame and electric arc processes.

If you want to keep posted on some of the most recent developments and applications of oxyacetylene flame and electric arc processes, write for a free copy of the illustrated booklet, "Airco in the News." Please address your requests to Air Reduction, Room 1656, 60 East 42nd Street, New York.

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ANYTHING AND EVERYTHING FOR GAS WELDING OR CUTTING AND ARC WELDING

THOR VS. KILOWATTS

(*Continued from page 120*)

This coil is so proportioned in relation to the capacitance of the system that when a line-to-ground fault occurs on one conductor, the lagging current which will flow through the coil is equal in magnitude and opposite in phase to the charging current at the fault. This gives a resultant zero current at the fault. The Petersen Coil, however, cannot clear a line-to-line fault. It is a fact that the majority of the faults at least start single-phase to ground. Some later become phase-to-phase faults because of high tower-footing resistance which permits the tower potential to rise above the insulation level of the conductors. The Petersen Coil has not been used very much in this country. It has been used to a greater extent throughout Europe.

Finally, let us look at some actual field comparisons of the three most widely used methods of protection. For example, a 35 mile, 220 kv. line, with an average span of 1100 feet, which was not protected by overhead ground wires tripped-out 138 times, while a similar line which was protected had only six failures during the same eight year period. It was also found that increasing the number of protector tubes from three to ten per mile eliminated failures completely on a 66 kv. line. Although this test was in operation only two years, the results proved the value of the additional installations. On a 226 mile line equipped with Petersen Coils it was found that of the 242 faults which occurred during a five year test, only 69 were not cleared by the coil. It is seen that these protective measures, while not entirely removing the danger of power interruption, have substantially reduced the number of uncleared faults.

LIVING OR DEAD

(*Continued from page 108*)

protein. Since the nucleic acid alone contained the phosphorus, the percentage of this element was naturally very small. However, upon removal of the protein matter it was discovered that the residual matter had a phosphorus content of well-known nucleic acids, and soon thereafter the nucleic acids of several virus molecules were positively identified. Unfortunately, the residual protein matter was so complex that little work was done with it. Indeed, the structure of the protein in a molecule of weight 50,000,000 could not even be written down. However, the amino acids of the protein residue have been isolated, and have included many well-known compounds.

Although the sciences of biochemistry and biophysics are at present in a highly experimental stage, the ground is being laid for comprehensive scientific synthesis. Man has, indeed, marched far toward the discovery of the nature of life in his research with the viruses. He has definitely established them as the link between the living and the non-living world. He has established their nature, for he has found them to be separate molecules of highly complex nucleoprotein. His work has brought him an immense store of knowledge about colloid chemistry that will be the basis of the study of the metabolism of life. Most important of all, the biologist's work has definitely instilled in him the idea that life can be approached by the non-living. Hence he has imitated the metabolic processes of many microörganisms by means of non-living systems. Furthermore, the new biological concept has given him the hope that some day, perhaps some day soon, the synthesis of life will be achieved. Then the science of biology will have been welded to the science of matter and the science of energy, and a universal scientific synthesis will have been achieved.

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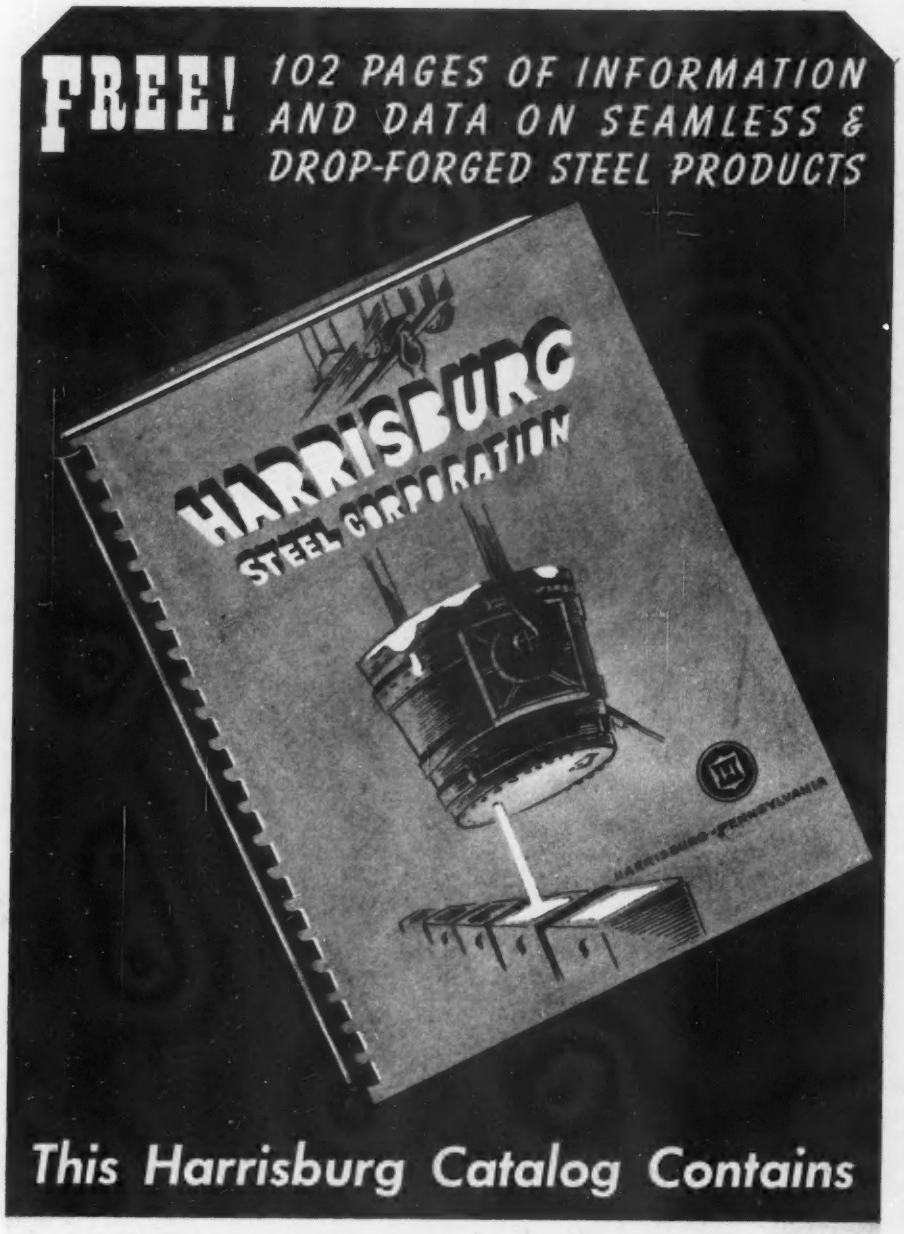
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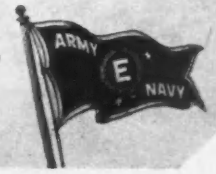


NEWS ON THE WIRES

(*Continued from page 113*)

network are connected by special circuits.

The mechanical operation of the Wirephoto is relatively simple, once given a photo-electric cell which is arranged to provide a quantitative sensitivity that will react differently to varying amounts of light. An ordinary positive photograph print is placed on a rotating cylinder on the transmitter (Figure 3) and an unexposed negative is placed on a similar, but enclosed, cylinder on the receiver. Just as in the case of the teletype, the principal problem is one of synchronization, but in the Wirephoto, the adjustment is far more acute, for the transmission takes place at the rate of 100,000 impulses per minute.

As the cylinder on the sending machine rotates, the scanning equipment containing the photo-electric cell moves on a carriage, similar to that on a machine lathe, horizontally along the picture. A beam of light is thrown on the picture through an aperture one one-hundredth of an inch square. This light is reflected from the print to the electric eye, where it is transformed into impulses which vary in intensity depending on the amount of light received by the cell — large or small as the light and dark portions of the picture rotate by on the cylinder. After suitable amplification, the current from the transmitter enters the receiver and activates an electric light bulb, the brilliance of which varies with the amount of current passing through it. The light from this bulb, located near the negative, is focused through a lens, so that it is reduced to pin point size on the film. The negative is thus exposed in exact proportion to the amount of light reflected by the original, thereby producing an accurate reproduction (Figure 4).

Because of the expense of the apparatus, the Wirephoto network (Figure 5) is still not sufficiently large to insure that a sending station will be close enough to the scene of any major news event to permit the desired rapidity of transmission; so a portable set was developed which can be transported anywhere, and hooked into the regular circuit by local telephone lines.

The most recent extension of the news gathering facilities of the press associations has been brought about by the adaptation of both the teletype and Wirephoto to radio transmission, thus making world-wide distribution a reality.

Something for you to do, afterward?

A MESSAGE TO MEN ON COLLEGE CAMPUSES

At no time in all the years we have been the confidant of young men approaching a career have we been so sure of the opportunity implicit in your future.

Today, your campus may not be of your own choosing. Your courses, your schedules almost all are pointed toward immediate necessity. Your career is set.

Have you a true conception of how much your special training means to your country? To Victory?

We think you do. But, honestly, don't you catch yourself wondering whether there is really going to be something for you to do, afterward? Are you sometimes in doubt of what's to come after NOW?

We say to you: There is a world to be made anew.

That world is going to offer you creative opportunity surpassing anything we old-timers have ever seen. You are going to have tools and materials and knowledge to work with such as no generation ever had.

We think you are going to find not only a country, but a whole world, waiting for your talents.

And we know that in this country you are going to find a point-of-view throughout industry which is a new thing under the sun. Already countless leaders in industry are laying plans which are based on flat acceptance of the principle that their first responsibility, after all-out production for war, is to make postwar jobs.

We at Alcoa are one group of such men. We are Imagineering now, for you. We intend to do everything we know how to make aluminum make jobs, whether they may be with us, or in a thousand other industries which will be using Alcoa Aluminum when it is again available.

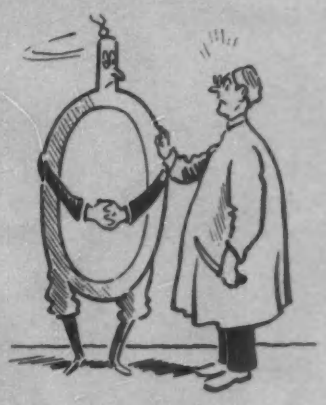
Wherever you are in service, you will surely be in, or around, or supported by, American airplanes. Will you remember two things: They are made largely of Alcoa Aluminum. *And*, the folks who make that metal are even now Imagineering for your future.

A PARENTHETICAL ASIDE: FROM THE AUTOBIOGRAPHY OF

ALCOA ALUMINUM

• This message is printed by Aluminum Company of America to help people to understand *what we do* and *what sort of men* make aluminum grow in usefulness.

G-E Campus News



PLASTIC SURGERY

MISTER FIVE BY FIVE had nothing on radio antenna enclosures until the "doctors" of the G-E Plastics Laboratory (PhD's, not MD's) went to work on the problem of streamlining. The result was a plastic housing that a plane hardly knows it's carrying.

That's just one wartime activity of the Laboratory chemists. They're also concocting plastics for fuse caps on mortar shells and for a vast variety of parts for battleships, tanks, and what-have-you's.

The name "plastics" covers a lot of different materials. These G-E chemists are applying the most precise and ingenious chemical techniques to increase that variety. So, if a special job requires a material with combined properties that no existing material has, they go to work to cook up an entirely new plastic to fill the bill.

The whole story can't begin to be told yet. But when it can, you'll be amazed at how far plastics have gone in wartime, and how many new peacetime jobs they'll be ready to tackle afterward.

PUT A NICKEL IN IT

NICKEL'S gone to war. But that doesn't mean that the juke box and pay telephone will soon be operating on a diet of "wooden nickels" and slugs. For every self-respecting coin-operated machine has a magnet attachment that refuses to accept all coins that do not have the magnetic properties of genuine ones.

So, when a new formula for the five-cent piece was needed in order to save nickel and copper for war service, it had to have magnetic properties close to those of the old-fashioned nickel. A number of metallurgical experts were asked for their advice.

Your guess is as good as the next as to whose advice was finally followed, but the formula submitted by the metallurgical section of the G-E Research Laboratory was pretty close to the one picked. The new "nickel" doesn't *have* any nickel in it, and has lost 19 per cent of its copper—and the metals saved are on their way to hit the Jap-pot.

JAP NAP

ONE night Hirohito had a nightmare. He dreamt that Shangri Las were springing up all over and planes were swarming over him like flies.

Perhaps that nightmare is nearer reality than his Imperial Nibs knows. For now, in practically no time at all, any open field, even though the ground is soft, can be transformed into a hard runway for American bombers starting off to make hay of enemy objectives.

To turn the trick, flexible steel mats are laid along the field. By means of resistance-welding machines guided by G-E electronic tubes, steel bars are automatically joined together to form these mats. The speed far exceeds that of a crew of hand welders.

On some dark night, in some deserted spot, our army engineers will swiftly unload these steel mats, joining them into a smooth, solid runway. And presto! Hirohito's nightmare will become a grim reality. General Electric Co., Schenectady, N. Y.

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Listen to the "Hour of Charm" 10 p.m. EWT Sundays on NBC and the G-E news with Frazier Hunt 6 p.m. EWT Tuesdays, Thursdays, and Saturdays on CBS and American (F-M) networks.

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